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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Forthcoming Events.

MARCH 30.

Junior Institution of Engineers:—Informal meeting in London. "Locomotive Maintenance," Paper by C. F. Adams.

Institution of Welding Engineers:—Ordinary meeting at Caxton Hall, London, S.W.1. W. Steele will read a Paper on "Bronze Welding."

Institute of Metals (Sheffield Local Section).—Ordinary meeting at St. George's Square, Sheffield. "Non-Ferrous Metals in Relation to Ferrous Metallurgy," Paper by W. H. Hatfield, D.Met.

Diesel Engine Users' Association:—Ordinary meeting in London. "Liquid Fuel from Coal," Paper by David Brownlie, B.Sc., F.C.S.

Institute of British Foundrymen.

MARCH 30.

London Junior Section:—General Meeting in London. Mr. Stanley V. Williams will read a Paper on "Notes on Alloy Steels."

APRIL 5.

London Branch:—Annual General Meeting in London.

A Case for Co-operation.

There are a number of localities that possess more metallurgical institutions than appear on the face of the matter to be either necessary or desirable. There is commonly the local section of the Institute of Metals, there are certain provincial Iron and Steel Institutes, and there are a number of local metallurgical societies. The parallel existence of so many bodies drawing to a certain extent at least upon the same field for the support and membership has the obvious result of weakening them all in some measure, and making it very difficult for each individually to secure sufficiently good lecturers or attendance.

The problem is on the way to solution in the Midlands. There exist in that district three separate organisations of the type referred to. There is firstly the old-established Staffordshire Iron and Steel Institute; secondly the Birmingham Metallurgical Society, which has done excellent work in its post-war re-incarnation; and thirdly the Birmingham Branch of the Institute of Metals. These three bodies recognised the difficulties inherent in the situation, and some two years ago they formed a Co-ordinating Committee. Its primary work was to formulate a single programme for the three societies, the members of any one being automatically eligible to attend any of the meetings. Some at least of these meetings are naturally of only sectional appeal, since the co-ordination of these three bodies implies the co-ordination of three groups of interests which may not coincide although they may overlap. The first group is, of course, concerned primarily with ferrous and the third with non-ferrous metallurgy. In order to preserve the balance and give due weight to this sectional appeal, meetings are held in turn under the auspices of each of the three societies. They are equally open to members of the other two, but the society principally concerned is responsible for the organisation, and, in fact, technically for the holding of the meeting. There is also an annual dinner in which all three participate on equal terms.

The example, so far as it goes, is extremely interesting, and other localities might consider very seriously whether it would not apply to their own similar problems. It does not, of course, go all the way. Members, especially those who have previously belonged to more than one of the organisations concerned, are not unnaturally beginning to ask why there should continue to be three separate societies with the consequent duplication of expenditure, and, hence, of subscriptions. It is obvious that any suggestion of sacrificing its autonomy and losing its individuality in an omnibus organisation would hardly appeal to any one of the societies concerned; they take a legitimate and commendable pride in their associations, their history—in many cases no short one—and their independence.

Whether the Co-ordinating Committee for the Midland area will succeed in solving the problem in whole or in part remains to be seen—and their action in the matter will be watched with interest.

It may be noted in parenthesis that the Institute of British Foundrymen stands a little apart from such groups, its membership being based upon a common concern with a process rather than with a material or group of materials.

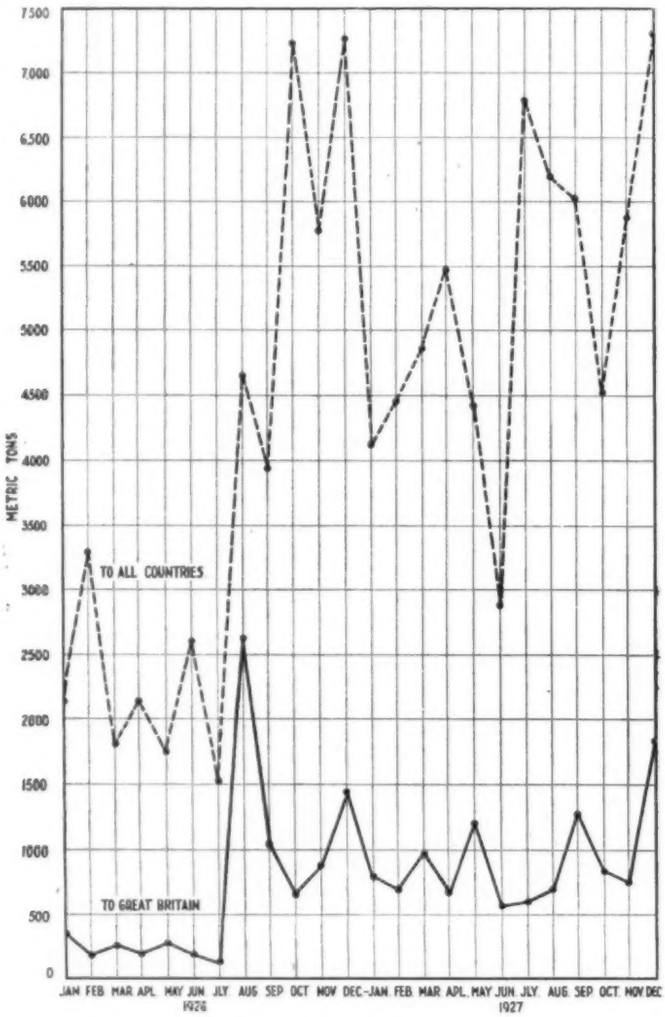
Winning the Industrial Race.

We were interested to learn from an American writer that industrial depression in that semi-continent is due to its mania for standardisation resulting in the man in the suburbs being dissatisfied because his purchases are exactly the same as those of the man living next door. The writer further points out what he considers to be the striking fact that despite the wonderful natural resources which the United States possess, and despite the enormous and closely-protected market of over a hundred million people, her manufacturers have not succeeded in overwhelming European industries. The author's actual words are "Mass production was admirably suited to the war era, but it will never win the commercial race. For as the world grows richer and more various in its tastes, it is the quality of Great Britain and not the quantity of America which will hold economic sway."

Coming from an American this is extremely interesting, but it requires to be kept within its correct perspective. It is recognised that with culture comes a desire for the incorporation of personal preferences in the objects with which an individual is surrounded, often verging toward the acquisition of the unique, but for the thousand and one utilitarian appliances essential for modern comfort, no striving for the incorporation of "personality" or the unique is ever envisaged. The vacuum cleaner, colliery-tub wheels, the "guts" of a motor car, and its tyres, a saucepan or kettle, and a typewriter, constitute but an iota of things on which there is scope for intensive mass production. Surely, this American writer should have limited his generalisation to a statement indicating that it is unwise of the Americans excessively to quantity-produce standardised articles of a character which cultured people reject on the ground that they are hall marked with the producer's personality (or, more usually, lack thereof) rather than the purchaser's personal prejudices. Obviously, the American precept that heavy mass production lowers the cost price and widens the salesmen's field, is and will remain for a long time to come a sound business proposition for the general mass of the manufacturing community. For the business possessing an exacting and specialised clientele, their proposition resolves itself into the unostentatious attraction of the right type of customer, and that's all.

Export of Belgian Castings.

The appended graph shows, in the clearest possible manner, the influence of the 1926 coal dispute. It is evident that the foothold then obtained has in an important degree been retained. More striking is the progress, dating from this period, that the Belgians have made in their exports to all countries, but it so happens that this increase very largely dates from the stabilisation of Belgian currency.



Export of Belgian Castings.

Cast-Iron Tanks.

By Practicien.

Although, as a general rule, one simply hates to be pessimistic, a brief survey of the iron trade will show that it is far from being prosperous. Some will endeavour to explain this bad state of affairs as resulting directly from the Great War. Others will offer other causes, such as unstable conditions in the European countries, whilst some will even say that conditions are not nearly so bad as indicated. What we really want, however, is a remedy not an explanation. Maybe we foundrymen have been content to rest on our laurels. Everywhere we see electricity, steel, ferro-concrete, etc., universally advertised. In almost every trade journal we see one of the other lauding its many advantages, until at last it is firmly embedded in our minds. But, alas, how often do we see those all-important words, *Use Cast Iron, etc.?* That is where the whole root of the trouble lies! Take, for example, the manufacture of storage tanks. At one time one could hardly imagine a tank without simultaneously thinking of cast iron. But not so to-day. We have at least two serious rivals in the form of steel and ferro-concrete. Again, one can buy a ferro-concrete or steel tank at lower cost than a cast-iron tank. Which is the better proposition, however, in the long-run? Without doubt cast-iron. Let us compare the advantages of a cast-iron sectional tank over one made of ferro-concrete.

(1) They are lighter in weight and *occupy less space* for the same capacity.

(2) *They are not rateable.* A point worth emphasising.

(3) They can be moved to another part of the building if required.

(4) *They are resaleable,* and have always *a scrap value.*

(5) They can be easily inspected. Also, any desired alterations such as outlets and inlets can be easily made.

The above advantages of cast iron over ferro-concrete in the manufactured articles such as storage tanks, should be at least enough to sway the decision of the purchaser who previously contemplated ferro-concrete tanks. Such points should be nationally advertised, and a special commission set up to deal with the campaign. If every iron-founder would subscribe five guineas per annum to such a committee the result would be surprising. If only the words, Use Cast Iron were advertised in every journal, on every railway platform, and on every prominent hoarding, the trade would surely benefit.

As regards steel tanks one has only to remember that steel corrodes much quicker than cast iron, and draw their own conclusions. One word before concluding—standardise your tank plates, for it is the one and foremost solution to cheapen production and wider adoption.

Random Shots.

Glancing again over the collection of schoolboy howlers that I recently presented to your attention, I find myself speculating as to the reasons for the tremendous "vogue"—as the ladies' journals would doubtless call it—enjoyed of late by this particular type of humour. Wherein exactly does the humour lie? A howler that is obviously manufactured, for instance, is merely tedious; clearly it must be genuine. A howler that is calculated also loses its point; it must be, not a shot in the dark that if it doesn't happen to be right may at least be funny, but a *bona-fide* statement which is believed to be true and accurate. The humour is closely related to that which we can still find in Mrs. Malaprop and all her tribe, and school examination papers are not by any means the only available source.

* * *

It was, for instance, a somewhat overgrown schoolboy who stated that "Capital can always obtain certain profits from guilt-edged securities," yet no doubt the gentleman in question would be the last to intend the implications of his remark. It is an excellent case in point—would you have seen anything funny in that if it had been written by an acknowledged Communist?

* * *

Here is another instance—this time in connection with the recent London County Council elections. A gentleman who was keenly interested in local politics wished to find out how much was to be inferred from the display of voting cards in suburban windows. He accordingly bribed his young daughter, in the best parental tradition, to make a systematic count. When the results were complete they ran as follows:—"Brown, 150; Smith, 95; Carter Paterson, 7; Pickford, 4."

* * *

And there is, of course, the very much older story of the extremely ordinary young man who was asked by an art enthusiast if he cared about Botticelli. "I told him I preferred Chianti," he informed a friend. "Why, you ass," was all the comfort he got, "Botticelli isn't a wine—it's a cheese!"

* * *

Cautionary Tales for Ironfounders (with apologies to Mr. Hilaire Belloc).

The Tale of Freddie, who had a Terrible Thirst.

The trouble was with Frederick Trench,
A thirst that he could never quench.
In infancy on milk 'twas slaked,
Later, on tea his faith was staked.
At last young Fred a job must find—
They wondered how he'd stand the grind.
He could not go festooned with cans
Of liquid: he tried driving vans
Of ales and stout; but soon, alack,
His boss just handed him the sack.
A bargee next he tried to be;
In hopes that water'd taste like—tea.
No luck—his parents wept and swore,
Threatened to turn him from the door.
An inspiration came to Fred,
Slow trickling through his sodden head;
"Why not a foundry, Pa?" he said.
"All founders have a mighty thirst—
That is the thing they tell you first.
Surely they'd make arrangements apt;
Provide some liquor to be tapped,
Or else divide the day on lines
To which a thirsty man inclines."
They tried it—Fred is happy now.
Work in a foundry doth allow
Time and the best companionship
For letting his sad taste go rip.

* * *

This week's genius—the salesman who was so good that he could have sold a Ford car to each of the Four Horsemen of the Apocalypse.

Marksman.

We regret that an article on "Some Experiences in Practical Moulding" was ascribed to H. Sutcliffe, whereas it was actually by Mr. A. Sutcliffe, who is so well known in Lancashire foundry circles.

"Safety First" in Industry.

At an Industrial Congress organised by the Home Office and the National "Safety First" Association, held at Caxton Hall, Westminster, on Tuesday, March 20, Mr. E. J. Fox (Managing Director of the Stanton Ironworks Company, Limited) read a Paper on "The Value of 'Safety First' in Industry," in the course of which he remarked that it was unfortunately one of the weaknesses of human nature to be careless, and to take risks. It could be said that accidents awaited one at every turn, and safety could only be assured where the meditated action was known to be dangerous. Moreover, most accidents occurred where that danger was minimised either by a continual repetition of the same act, or through thoughtlessness in not realising the danger ahead. Such being the case it would seem human to adopt any possible steps to protect persons from accidents, the possible risk of which could only be kept constantly in their minds by some continual process of being reminded of their presence.

The speaker's experience was confined to an undertaking occupied in ironstone and limestone quarrying, coal-mining, brickmaking, the manufacture of pig-iron, and the production of various classes of foundry work, all of them embracing operations which lent themselves to accidents, and which care only could help to reduce.

For dealing with accidents there were eight fully-equipped ambulance houses, served by twelve hospital-trained nurses, working under the supervision of a fully-trained lady superintendent. Supplementary to these ambulance houses there were installed throughout the different sections of the establishments a series of "First Aid" boxes, under regulations laid down by the Home Office. The number of attendances at these eight ambulance houses exceeded 4,000 per month, the actual number for the month of January last being 4,351, of which 1,140 were new cases and 3,211 cases for redressing; so that of about 4,000 cases dealt with per month, about one-third were new cases, many of which in the ordinary way would receive no treatment, and certainly not continued treatment, until they had assumed a more serious condition. The total number of new accidents dealt with at four of the ambulance houses, which were under the control of the Home Office, during the year 1927 was 9,331, and of these only 519, namely, 5.5 per cent., came on to compensation.

The large proportion of small accident cases, not reportable to the Home Office, but each of them a potential danger from the point of view of risk of becoming a more serious case, and consequently becoming entitled to compensation, brought out the necessity of reducing the number of accidents by preventive means, and it was this disclosure of facts at the ambulance houses which prompted the necessity of introducing "Safety First" methods into the speaker's organisation. The thorough system of treatment in these ambulance houses had disclosed two things: (1) That the number of accidents requiring to be reported to the Home Office out of the total number of accidents occurring were in the minority, due no doubt partly to the continued treatment enabling the

Table I.—*Showing Reduction in Compensation paid at Establishments associated with Four Ambulance Houses under the Control of the Home Office:—*

	Compensation paid during year.	Approximate number of men.	Per annum per man employed.	Compensation per case per annum.
	£		£ s. d.	£ s. d.
1922 ..	4,377	4,091	1 1 4	8 14 4
1923 ..	6,196	4,847	1 5 6	9 9 9
1924 ..	5,742	5,160	1 2 3	8 6 2
1925 ..	2,969	5,121	0 11 6	4 15 5
1926*..	2,198	2,596	0 16 11	5 17 2
1927 ..	2,070	4,719	0 8 9	4 2 9

* Establishments shut down for eight months.

men to remain at work and avoiding more serious development; and (2) that those cases away from work and receiving compensation were enabled by daily attendance at the ambulance houses to return to work sooner than otherwise.

The compensation paid for the past six years at the establishments falling under the four ambulance houses under control of the Home Office, showed a satisfactory decrease, as indicated by Table I.

The compensation paid for the past six years at the establishments falling under the three ambulance houses under the control of the Ministry of Mines was as shown in Table II, the compensation indicated being limited to the first twenty-six weeks' absence from work:—

Table II.—*Showing Compensation Paid during Six Years at Establishments under Three Ambulance Houses under the Control of the Ministery of Mines.*

	Compensation paid during year for first 26 weeks only.	Further compensation beyond first 26 weeks.*	Approximate number of men.	Per annum per man employed.	Per case per annum for first 26 weeks only.
	£	£		£ s. d.	£ s. d.
1922 ..	8,227	—	3,777	2 3 6	7 15 2
1923 ..	8,832	—	3,795	2 6 6	7 1 5
1924† ..	6,329	8,361	4,126	1 10 8	5 4 9
1925‡ ..	5,187	9,593	4,268	1 4 3	4 7 1
1926—Strike	3,015	10,771	2,660	1 2 8	3 16 6
1927 ..	3,738	13,400	3,992	0 18 8	3 17 0

* Including commutations and fatals. † One ambulance house at work. ‡ Three ambulance houses at work.

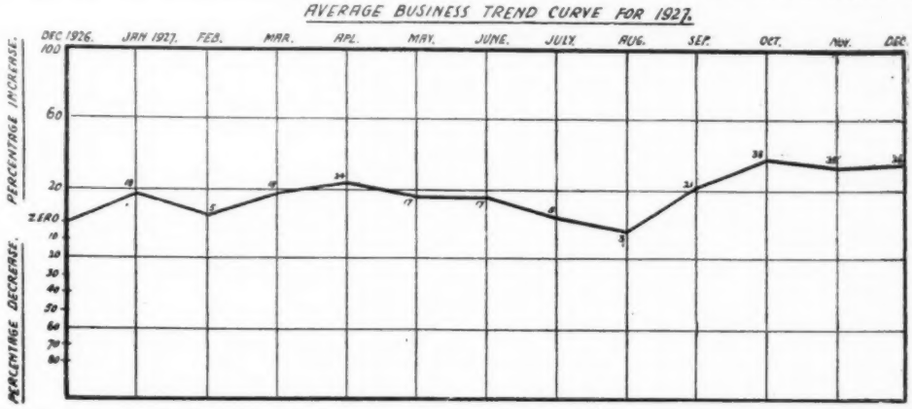
In passing, it might be of interest to state that the complete equipment and provision of the larger ambulance houses cost from £750 to £1,000 each, and the smaller ones (corrugated-iron buildings), with the same equipment from £300 to £400. The cost of running each ambulance house, excluding lady superintendent and outside visitors, but including nurses, cleaning, surgical stores, etc., was £350 per annum each, if open during the day time only, and £750 per annum each if open day and night.

Proceeding, Mr. Fox said that at each establishment "Safety First" committees had been, or were being, instituted, and these included the foremen as a whole, and, in some cases, representatives from the men. The meetings were held monthly; the chair was taken in rotation by one of the principal officials concerned with the establishment, and the "Safety First" department acted as secretaries. At each of the meetings some six of the outstanding accidents which had occurred at the establishment during the previous month were investigated, notice of the cases having been included on the agenda. The display and continual renewal of "Safety First" posters must only be looked upon as an outward and visible sign of a movement requiring to penetrate a good deal deeper: and as any good effects from "Safety First" efforts could only be achieved gradually and by dogged perseverance, so the weekly changing of the posters could be looked upon as an indication of that perseverance being maintained, at the same time helping to create an atmosphere throughout the works of "Safety First."

Vickers, Limited, announce profits of £1,275,995 and interest charges, £172,500; depreciation, £100,011; trustees' remuneration, £500; net profit, £992,985; brought in, £134,868; total, £1,127,853; preference dividends, £418,190; ordinary dividend, 8 per cent., less tax; reserve fund, £238,211; carried forward, £208,722.

A Foundry Business Trend Curve.

It is difficult to refute that the state of trade in the foundry industry, supplying as it does the basic needs for the commencement or continuation of every other trade, probably gives a truer delineation of the actual state of national business than any other factor. The unemployment figures, the Board of Trade Returns, the coal output, the traffic on the railways, have all been shown to require consideration with related factors before they can be aligned with the trend of national business. For instance, only last week the returns showed decreased coal output and decreased unemployment.



It is extremely difficult to assess the current business activities of the 4,000 odd foundries in Great Britain, and therefore recourse has been made to the commercial activities of a number of reputable firms who supply the needs of this great industry.

The business trend curve reproduced herewith has been evolved by the council of the Foundry Trades Equipment and Supplies Association, Limited, of Avenue Chambers, Southampton Row, London, W.C.1. It shows how general business steadily improved last year; how the summer holidays adversely influence trade; how there is a slowing up just before Christmas, when so many firms have their annual stocktaking.

The object of evolving this curve is to provide a basis upon which any firm supplying the foundry industry with raw material or plant can ascertain whether they themselves have received orders commensurate with the activity indicated by it.

Continental Steel Trust.

Supplementing the information already published concerning the proceedings at the recent Paris meeting of the Managing Committee of the Continental Steel Trust, it is stated that the reduction of the penalty to $1 per ton for exceeding the inland quota of production remains in force for the second quarter. The monthly export quota has been raised by 50,000 tons. The allotment was originally fixed on the basis that the exports should be 75,000 tons per month less than they had been in a definite period of comparison, so that by increasing now the contingent by 50,000 tons the restriction only amounts to 25,000 tons as compared with the period of comparison.

No date has as yet been fixed for the next meeting. Nor has anything been settled about the new President to succeed the late M. Mayrisch.

Spun Pipe in Canada.—Gartshore-Thompson Pipe Company, Limited, has in the course of construction at Hamilton, Ont., a new foundry where they will manufacture cast-iron pipe by the centrifugal method. Much new equipment is being purchased, and included in the installations to date are three electric cranes of six-, five- and two-ton capacity respectively. Two twenty-five-ton and one three-ton electric hoists have also been installed. This equipment was furnished by the Herbert Morris Crane and Hoist Company, Niagara Falls. This foundry, it is expected, will be in operation by April, and will be one of the most modern plants on the North American Continent.

Foundry Purchasing.—XXIII.

By Eric N. Simons.

Reverting to requisitions themselves, it is advisable that these, either singly or in their summarised form, should be inspected by the buyer before being passed over to the order clerk. Trifling requisitions can be excluded from this proviso if desired, but important orders should be examined by the purchasing agent himself, or at least his chief assistant. The essential things to look for are (1) the authenticity of the signature on the requisition form; (2) the completeness or otherwise of the details given; (3) the quantities, *i.e.*, to make sure that these are not greater than the buyer has power to order, or that they are not excessive or unsatisfactory from a buying point of view. (An example is high-speed steel. The department might order this cut to dead lengths, thereby incurring an "extra" of 10 per cent. on the standard price. Yet dead lengths might not be essential, and random bars from the steel-maker's stock would suffice. Similarly, less than a given weight of steel in certain sizes involves an "extra"! The buyer, on examining the requisition, would be enabled to point this out to the department concerned, with a view either to increasing the quantity ordered, or to postponing the order until such time as the proper quantity could be made up.) (4) The specification, *i.e.*, to make sure that he has a copy of this for reference, or that the details given are comprehensible.

It will sometimes happen that the goods requisitioned are such as form the subject of a contract already made with a particular supplier. In other words, their price is pre-arranged, together with the conditions and time of delivery. As a rule, orders for materials of this kind can be made out immediately, assuming, of course, that the proper precautions have been taken against error.

In this connection it must be pointed out that it is often feasible to arrange with a supplier to retain materials in store until such time as they are needed by the purchasing firm. For example, a buyer may contract ahead for 1,000 tons of some raw material at an advantageous price. He knows from his records that in the course of time he will use the entire quantity, but he has not enough warehousing or storing space to enable him to take delivery at once. He must, therefore, arrange with the supplier to deliver portions only as and when required. An essential of any such contract is that the time intervening between the first delivery and the last should not affect the price at which the contract is placed. In this way the buyer is safeguarded against increases of price over a long period. At the same time, it is customary for the buyer to be given, or to claim, the benefit of any fall in price over the period covered by the contract. Arrangements of this sort are not quite so adverse to the supplier as they seem. The long contract enables him to regulate his output, to purchase his own supplies of raw materials on favourable terms, and, in short, to keep his works running steadily instead of intermittently, and there are obviously other advantages.

Sometimes the buyer will have to take it upon himself to buy either more or less than the official requisition calls for. For example, by purchasing a larger quantity, he might be able to secure lower transportation costs. A large number of different factors enter into any decision of this sort, and he will have to balance such advantages as lower price or lower carriage charges with such disadvantages as uneconomical stocks, extra insurance cost, decreased general storage room, potential loss through pilfering, deterioration, and so forth.

Having received the requisition in the buying room, and having taken all the necessary steps already outlined, the next procedure, for all those requisitions that cannot immediately be transformed into official orders, is to obtain prices. If the requisition deals with goods for which no special contract price has been arranged, or if the old contract has come to an end, it is necessary to obtain new quotations. A typical inquiry form is shown in Fig. 1.

Mark Correspondence relating to this inquiry "Purchase Department."

INQUIRY.

From JOHN SMITH & CO., LTD.,
Royal Works,
BIRMINGHAM.

To WALTER JONES & CO., LTD.,
Imperial Works,
READING.

8/6/28

Monthly Accounts are paid on the last day of the month following delivery.

(1) Please quote us your lowest price .....
(2) Delivered.....
(3) Time of delivery .....
(4) For .....

NOTE—
If for shipment and packing required
(5) State cost of packing .....
(6) Approximate nett and gross weights and dimensions.....

IMPORTANT—
Please quote to the particulars given above and name the earliest time of delivery you could give.

Signature.....

Fig. 1.—Typical Inquiry Form.

The statistical clerk will have in his possession, as already indicated, the needful data regarding sources of supply, whether in the form of records of past purchases, or in the form of catalogues and price lists. The buyer will have to use his own judgment to a large extent in deciding to how many firms, and of what kind, the inquiry should be sent. For instance, a requisition for a small quantity of material is not worth sending out in the form of an inquiry to a dozen firms, but a requisition for an overhead crane undoubtedly is. The object of sending out inquiries, it must be remembered, is to obtain the minimum prices consistent with good material and adequate delivery.

It is not necessary to write separate inquiry letters to every firm approached. The usual practice is to duplicate, or, more accurately, multiplicate, the inquiry on the typewriter, fill in the names of the respective firms afterwards, and make one file copy on which the list of firms approached is typed. This saves labour, and avoids clogging up the files with surplus matter. Until the order is definitely placed, the file copy should be pinned to the requisition and kept at hand.

Eventually the various quotations will come in. A pencil tick should be placed after the name of each supplier as his quotation is received, so that the outstanding quotations can be seen at a glance. Any tardy firm can then, if desired, be urged to submit its price without delay. A practice frequently adopted is for a supplying firm to send its quotation to its salesman for the district concerned, so that he may call upon the buyer and negotiate direct. There is nothing harmful, and often a real benefit to the buyer, in this procedure, so long as the latter does not too hastily commit himself. He is able to elicit information that the bald quotation does not, perhaps, contain, and to extract intimate details concerning the ability of the firm in question to supply his requirements, details such as he could not hope to extract from any but a loquacious and not too discreet traveller. It is often the case—though not invariably—that the salesman has a "margin" with which to negotiate if he finds the order likely to pass him on the officially quoted price. For example, if the quotation is for 20s. a cwt. of whatever the material may be, and he learns that this price is too high, he may have authority to drop down as low as 18s. 6d., if he think he can get the order at this price. The buyer's task is to find out by the exercise of acumen and insight whether the salesman has such a margin up his sleeve. If he perceives that he has, then—whether the price be high or low—it is his business to obtain it, just as it is the salesman's business to get the order without using the margin, if he is acute enough to do so.

One disadvantage of this method of quoting by salesmen is that it often delays a quotation longer than the buyer desires, owing to inability on the representative's part to present it at once. For this reason it is always good policy to stipulate on inquiries the date on which quotations must be received. In fixing this date, the buyer must bear in mind that certain quotations involve a great deal of difficult and extensive calculation on the supplier's part, and that if a close and economical offer is desired, sufficient time must be given to allow of these calculations being completed.

Company Meeting.

Metropolitan-Vickers Electrical Company, Limited.—The annual meeting was held on Friday last in London. Major-General Sir Philip A. M. Nash (the chairman) said that the profit for the year amounted to £254,748, as against £273,646 for 1926. After transferring £25,000 to general reserve, which would then stand at £550,000, the board proposed to pay dividends of 8 per cent. on the 8 per cent. cumulative preference shares and 6 per cent. on the ordinary shares, leaving £99,676 to be carried forward, as against £98,052 brought in. Following on the change which had taken place in the control of the company, Mr. Bernard D. F. Docker had been elected a director, as well as deputy-chairman, in place of Capt. Hilton, who had resigned his seat on the board on taking up the position of managing director of United Steel Industries, Limited. There had been a record output of finished product from the company's works during 1927, which showed that the works had been very fully occupied, but the result of this activity had been the making of a profit which was entirely inadequate to the volume of turnover. The year commenced with a very heavy order book, and the company obtained new orders practically equivalent to its output, and, therefore, they started 1928 with a very satisfactory accumulation of unexecuted orders of practically the same amount as a year ago. The present order book consisted of about equal proportions of home and export business. Conditions in the home market had for some time been what he would describe as sub-normal, i.e., the demand for heavy electrical plant had been below normal, principally owing to the hold-up of power-house development in the country, inevitable during the stages of consideration and discussion of the Electricity Supply Act, which came into force in the middle of last year. Now that the Central Electricity Board was at work, the demand for heavy plant was bound to improve, but time must be allowed for this body to launch their schemes and bring them into being. There were also indications of an increased demand for electrical plant from home industries, due to improved conditions.

Sheffield Students to visit London.

The members of the Sheffield University Engineering Society are spending the first four days of next week in London, where they are to visit Woolwich Arsenal, the National Physical Laboratory, and various public works.

Making a Test-column Casting.

By F. C. Edwards.

It is no easy task to make a large, grey-iron casting which will machine up perfectly clean on all surfaces. However plain the job may be—and "plain," by the way, is not here synonymous with "simple"—it is only by the closest attention to moulding and metallurgical details that sullage and porosity can be kept completely at bay. In the case of a "one-off" job, the difficulty is accentuated. For the expense of special moulding tackle—justifiable, of course, where it can be spread over a number of castings—must be ruled out, or kept down to negligible proportions, when a single casting has to carry the cost. An interesting example of this kind, made in green sand, 10 ft. long, 3 ft. square, and weighing about 4 tons, is illustrated by Figs. 1 to 5.

The casting is seen in Fig. 1, with runners attached to show the method of gating. (This will be dealt with later.) The external apertures, it should be noted, were located on the original blue-print near the outer edge of their respective cores, as shown at A, Fig. 2—which represents a cross section of the casting. Such apertures serve to support the cores. Now, with the body core made up of vertical sections (unavoidable, on account of the internal webbing) as seen in Fig. 4, the apertures, A, would afford but a lop-sided support to their cores. And this, since chaplets in an all-machined casting could not be entertained, would render more difficult the work of coring up the mould as compared with central supports. Each section would need to be held upright until its complementary half was placed in position beside it. Moreover, with the apertures as at A, the necessary "handing" of the corebox might lead to complications in making the cores. Safety, therefore, as well as economy, suggested a modification of the design. The attention of the drafting-room was accordingly drawn to this snag—*before* the pattern was proceeded with. And it was found (as almost invariably happens in such cases) that the design could be altered, with no detriment to the ultimate purpose of the job, to suit foundry requirements. The apertures were consequently not only centralised, but were also increased in width from 3 in. to 7 in., to give a better bearing surface for the cores, as shown at B.

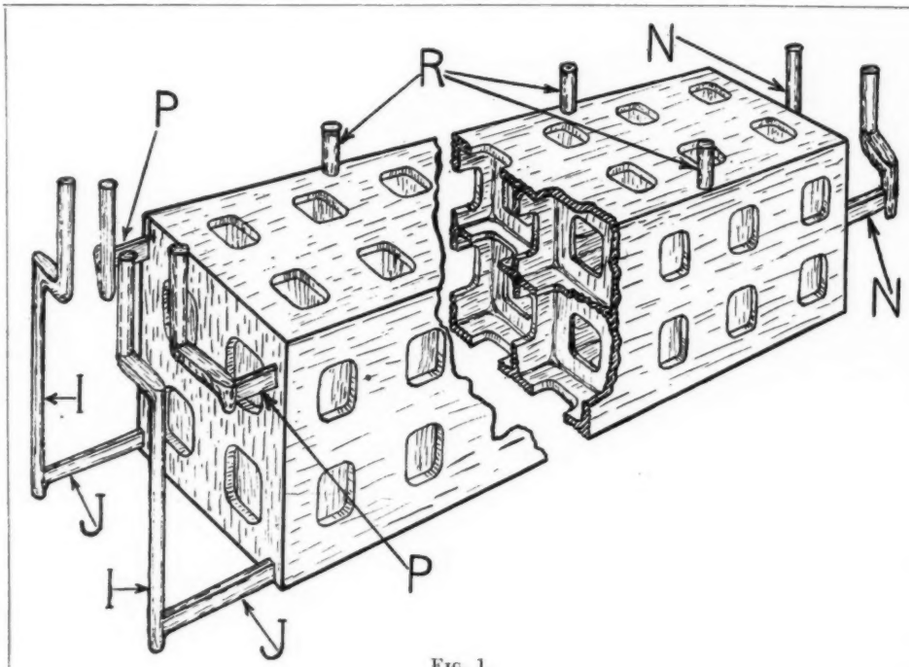


Fig. 1.

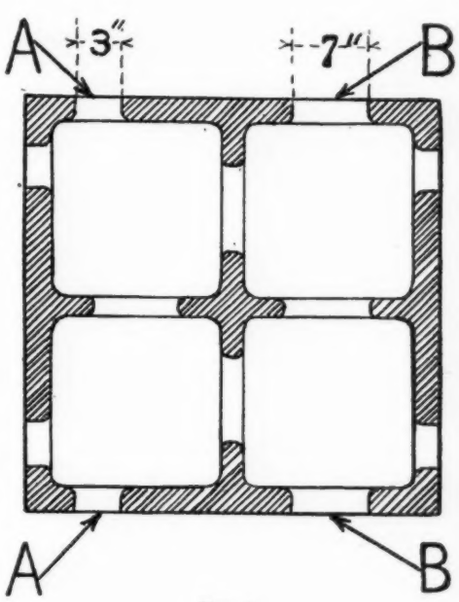


Fig. 2.

The Pattern.

A plain, "boxed-up" block constituted the pattern. The sides and ends were given a moulding taper of $\frac{1}{4}$ in., and a minimum of $\frac{1}{4}$ in. was allowed on all surfaces for machining. The depth, as moulded, was made to "standard" rule—*i.e.*, there was no allowance for vertical contraction of the casting. The result justified this departure from ordinary practice; for the casting came out the same depth as the pattern.

A special feature of the pattern was the entire absence of coreprints. The usual method, of course, in such cases, is to affix coreprints to the top and bottom of the pattern, and to employ loosely-wired prints on the sides and ends, or, alternatively, fixed "tail"-prints.

Efficient patternmaking, however, observes no stereotyped methods. In this case, dispensing with coreprints secured several advantages. Time and material were saved in the patternshop; the pattern came out of the mould easier than if its sides had been "serrated" with coreprints; mending-up the mound round the coreprints and the subsequent stopping-up after the insertion of the cores were both eliminated. With no projecting cores in the top, again, there was no risk of crushing when the cope was lowered in position. Even fettling was simpler than if separate cores had been employed to cut through the sides; for the unavoidable fin came to the outside surface, being removed, automatically, when the casting was machined. As a guide to the moulder, however, the apertures were distinctively painted on the pattern.

Moulding.

The sequence of moulding operations (illustrated by Fig. 3) was as follows:—On the bottom of trough-shaped pit, excavated in the foundry floor, about 15 ins. deeper than the pattern, a coke bed, C, 4 in. thick, was laid down, with a covering of straw, D, to keep the sand from blocking up the inter-spaces of the coke bed. The coke bed, of course, is an essential feature of this type of mould. It serves as an immediate asylum into which the gases generated at the bottom of the mould may escape. The gases were conveyed to the outer air by two 4 in. dia. pipes, E, placed diagonally near the ends of the mould. Black sand, F, 6 in. deep, and facing sand, G, 4 in. deep, was then firmly rammed and levelled. The facing sand was composed of 60 per cent. red sand, 20 per cent. black sand, and 20 per cent. coal dust.

The pattern was placed in position, marked round to guide venting, and removed. The bed was then sprigged—to enable it to withstand the "wash" of the metal—and vented. The vents, H, $\frac{1}{4}$ in. in dia., and extending right down to the coke bed, were stopped up at the top to prevent the entry of the molten metal. The bottom of the mould was sleeked, needle-vented, and the pattern replaced on the bed. Downgates 2 in. in dia., and bottom ingates, 3 in. by $\frac{3}{4}$ in., were positioned as indicated by I and J respectively, Fig. 1. The greater sectional area of downgate over ingate, of course, tends to ensure delivery of clean metal to the mould: it allows the scum time to rise to the top.

As a reinforcement at the lower part of the mould—which, in a deep job of this kind, is subjected to great strain when the casting is poured—a row of pig-iron, K, Fig. 3, was placed at a distance of 3 in., all round the pattern. The pig was clay-washed to prevent the mould peeling away. With a 2-in. layer of facing sand against the pattern, the mould was rammed up to 3 in. above the pig, vented down to the coke bed, and another row of pig, L, put down. The previous operation was repeated, the third row of pig, M, was laid down, and gates, N, Fig. 1, were located about half-way up the job. On nearing the top of the mould, gates, P, Fig. 1, were positioned, and bearers, Q, Fig. 3, arranged to receive the outside frame of the cope. This was tried on, being adjusted, of course, to bring the vent holes in the cores between the bar spaces. It was then staked in position, removed, the mould rammed up level with the top of the pattern, and the joint made.

In the absence of coreprints, the painted apertures served for positioning the chaplets. Two of these, with stems as high as the cope for subsequent weighting, were placed over each aperture. A spike was also driven in the centre of each "print" as a guide for the tube—used later on—to continue the vents from the core through the cope. It also enabled the moulder to keep the lifters in the cope clear of the tube. The pattern was covered with 2 in. of facing sand,

and the cope replaced. After the gate sticks and risers, R, Fig. 1, had been positioned, the usual cope operations followed. The sand was well

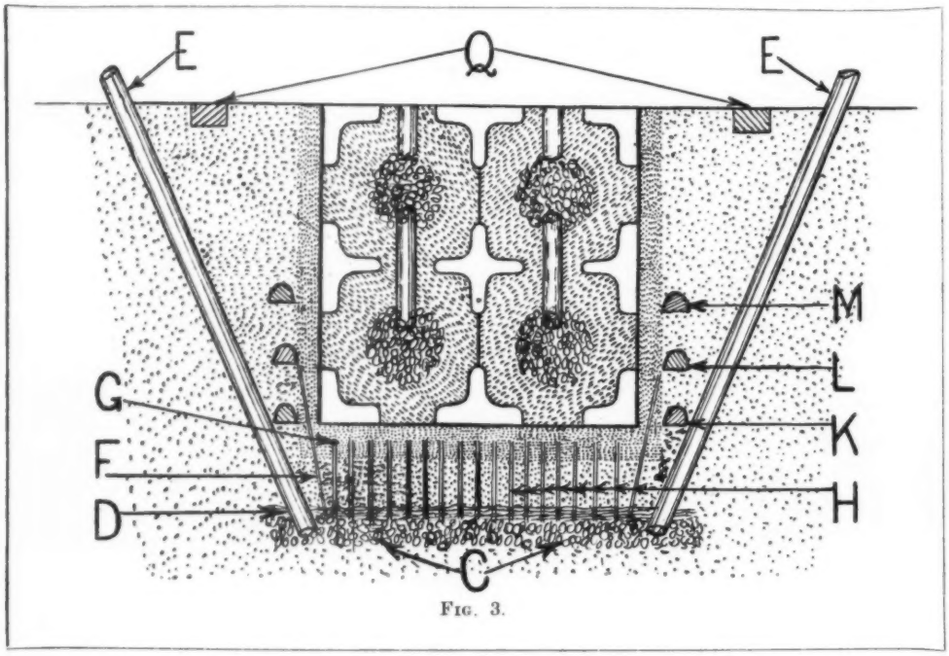


Fig. 3.

"tucked" in under the box bars; the cope was lifted; rammed up; vented; removed; sleeked; needle-vented; finished; and blacked with liquid plumbago, and similarly with the mould. After the withdrawal of the pattern the mould was well sprigged round the gates, needle-vented, finished, and blacked. Both cope and mould were skin-dried by means of fire pots. These were slung, in the case of the mould, from the top.

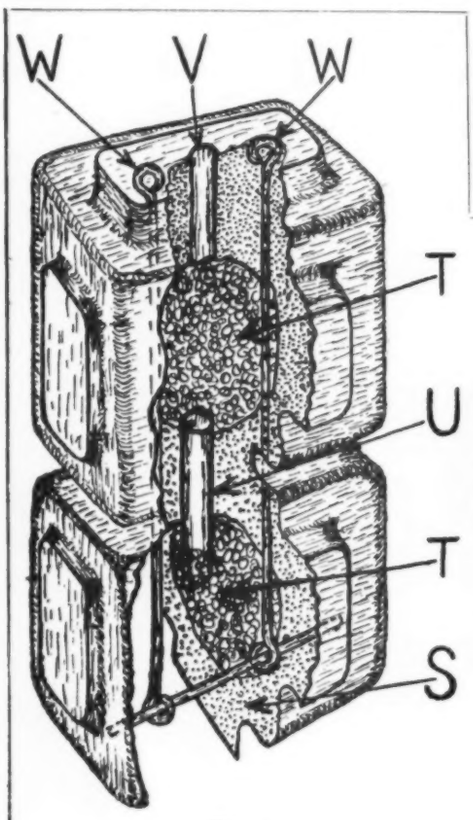


Fig. 4.

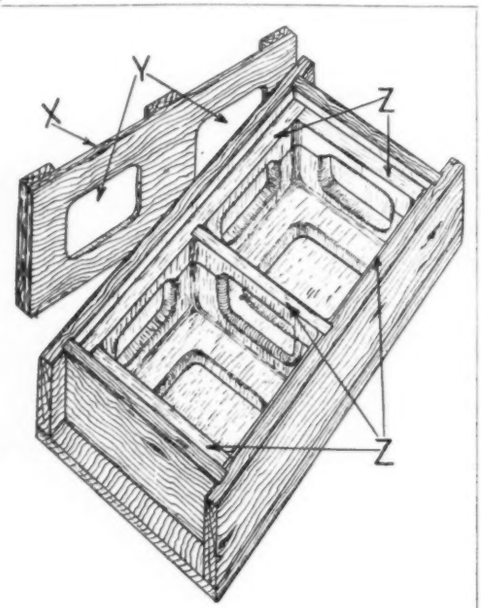


Fig. 5.

The Cores.

The cores were made in vertical sections, as seen in Fig. 4, which is a section broken open to show the interior construction. They were composed of an outer shell of oil sand, S, and an inner body of ashes, T. The necessary vent communication between lower and upper ashes was supplied by means of a 2-in. dia. steam pipe, U, dried in the core. This pipe served also to strengthen the core at the reduced section. To form the top vent hole, V, a tube was pushed through to the ashes after the core was made.

It will be seen that the wrought-iron lifting rods, W, carry cross bars through their bottom loops. These were employed instead of the ordinary cast-iron grids. They were simpler and more economical than grids. Furthermore, they were easily detached from the cores when the casting was fettled, whereas the extraction of grids would entail their destruction. This, incidentally, exemplifies one of the main advantages of the oil-sand core: it is almost self-supporting.

The cores were all made out of one box—shown in Fig. 5. The oil sand was laid against the bottom and sides of the box—like paste round a piedish. The lifting-rods were suitably positioned, the body of the core filled in with ashes, and covered with a layer of oil sand. Piece X was then placed on the top of the box to obtain projections of ¼ in. from the spaces, Y. When two cores were put together at these projecting surfaces a space was left to form the web, 1 in. thick, as seen in the cross section of the casting, Fig. 2. For the side apertures, loose ribs, Z, were employed, jointed, of course, half-way down the box. These were drawn outward before the core was removed from the box, and their spaces filled with black sand as a temporary core support. It may be mentioned that the core box was made ⅛ in. under the required size all round, to allow for the swelling of the cores in drying. This was found, on coring up the mould, to be the correct allowance. To produce the necessary right- and left-hand cores, blocks (not shown in the sketch) were moved from one side of the box to the other. These blocks were made to fit the apertures, and were 1 in. in thickness. They reduced the depth of the aperture from the outside casting thickness to that of half the web.

Coring up the Mould.

Coring up the mould was very simple. There were no prints to mend up, and no projecting cores to crush the mould. The cores were merely lowered into position, and their lifting-hook holes stopped up. A ring of whitening was dribbled round each core vent hole, and the cope tried on. Where the whitening did not indicate a close touch round the vent holes a little loam was used to keep the metal out of the vents. The cope was replaced and the gate and riser boxes prepared. The riser apertures in this case were formed at a lower level than the top of the gate box. They would thus function as "run-offs," through which the lighter sullage could be forced out of the mould after the latter was filled. Strong bars, to carry the weights, were placed over the chaplets, and wedges were inserted where necessary to give a close bearing between chaplet and bar. The whole was securely weighted.

Pouring the Casting.

As will be understood from the gates shown in Fig. 1, the casting was poured from each end. All gates, to begin with, were stoppered. Pouring commenced at the end having the bottom ingates, J. When the gate pound was nearly full—thus giving time for the scum to float to the top—the stoppers over downgates, I, were removed, and the heavier, clean metal allowed to enter the mould at the lowest ingates, J.

As soon as the mould was estimated to be about half full of metal pouring was proceeded with at the opposite end of the job. Here, with the removal of the stoppers over gates N, a fresh supply of "hot" metal was released. This would have the effect of breaking up any sullage or crust on the rising metal in the mould. Almost immediately afterwards the stoppers over ingates, P, were removed, permitting the entry of further "hot" metal. Pouring was continued for a few seconds after the mould was full. This brought the "run-offs" into active eruption, as referred to above. It may be added that the result fully justified the method adopted. The entire exterior of the casting machined up without a blemish.

New Iron Ore Resources of Germany.—New extensive resources of iron ore are being tapped in the Hunsrück, the high ground between the Rhine and Mosel, by the Thyssen and Krupp firms. The former concern has so far advanced its works that by the end of February the daily despatch of ore to the Ruhr will reach 200 tons. This will be loaded into barges at Bingen. Krupp's borings and works are not quite so far advanced, but within about two months their output will be even more than 200 tons a day.

Ramming Moulds by Sand Slinger.

By Daniel Sharpe.

The principle aimed at by any system of sand moulding is to deposit sand round a pattern in such a manner as to give the resulting inflow of metal the best conditions in which to cool and retain the permanent shape of the pattern so moulded. To obtain these conditions it is necessary that the sand should be rammed sufficiently firm to withstand the pressure of the high temperature metal being poured into it, that the material should be of a sufficiently refractory nature to prevent the sand burning in to the metal, and that the density of the rammed sand should not be such as to preclude the free escaping of gases formed in the mould, or in the sand forming the mould. These gases may be carbonaceous gases or merely gaseous moisture or steam. It is also desirable that the sand should contain the minimum moisture necessary to hold it bonded, more particularly in green sand.

It is obvious that to obtain a homogeneous ramming of sand to present these conditions it is an advantage to apply the sand in deposits from the bottom to the top of the mould, ramming each deposit or layer with a uniform pressure throughout. This is the condition obtained in ordinary hand moulding, and it is also the condition obtained, but in an improved sense, by the application of the sand-slinger. The only successful sand-throwing machine at present on the market is that built under the Beardsley-Piper Patents, and is the one with which the author is familiar.

The principle adopted by the patentees was the introduction of a constant stream of moulding sand into the side of a high-speed single-blade impeller.

After considerable experiment, and as a result of much careful calculation, an arrangement has been arrived at which permits of a definite feed of sand into the impeller, to produce a wad of definite size best suited to the type of mould being produced.

Fig. 8 illustrates how the sand is collected by the impeller blade, centrifugally thrown to the outer edge, where it bears on a specially fitted liner until it escapes through a discharge opening. Sand-slingers are running at speeds of 1,200 r.p.m. to over 2,000 r.p.m., and can now be designed to take any voltage, and produce a given impact of the sand, whether green sand or dry sand. The sand travelling at 6,000 ft. per min. approx. 1 mile per min. The wad of sand discharged from the high-speed rotating impeller travels as a definite unit, and might be likened to a moulder's rammer. This wad of sand not only deposits itself in a dense form in the mould, but it rams the sand which has been previously so deposited. By moving the impeller back and forward over the surface of the moulding box a definite layer of sand can be placed right over the whole area, and the entire box brought up in regular layers until it is completely filled. If it is desired to arrange for a soft corner to allow of contraction strains being taken care of, this can readily be arranged by holding the head in a more or less fixed position at this particular corner. The piling of the sand immediately produces a less dense ramming than is obtained by regularly depositing the wads evenly over an area.

In a modern adaptation of the head the replacement of the cup and liner is a matter of two or three minutes, and the attachments are so arranged that they can be very readily got at.

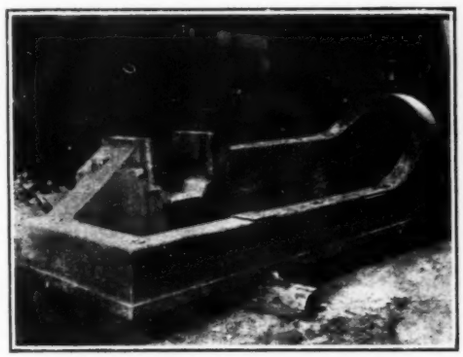


Fig. 1.—Shows a 15-ton Engine Bedplate Made in the Mould shown on Fig. 2.

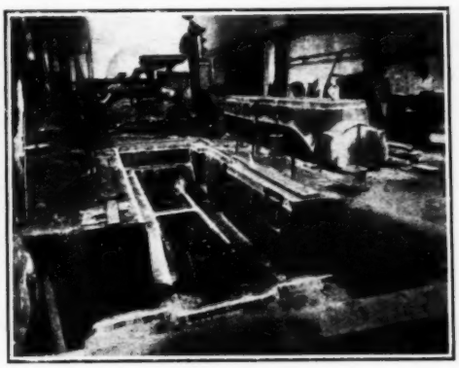


Fig. 2.—Shows Mould for Fig. 1.

It is important that it should be understood that the impeller head of the sand-slinger is the heart of the machine, the other parts are merely a means towards feeding of this head and a provision for carrying it flexibly over the mould where the ramming is to take place.

A Classification of Foundries.

Different foundries call for different treatment, but it has been found that almost all phases of moulding can be classified and dealt with under four different headings:—(1) Mass production castings, dealing with quantities of, say, 500 to 5,000 castings per day; (2) quantity-production, where patterns have been prepared to be used on stripping plate or turn-over machines, and where an output of from 10 to 50 or even 200 castings per day are required; (3) light jobbing castings, and (4) heavy jobbing castings.

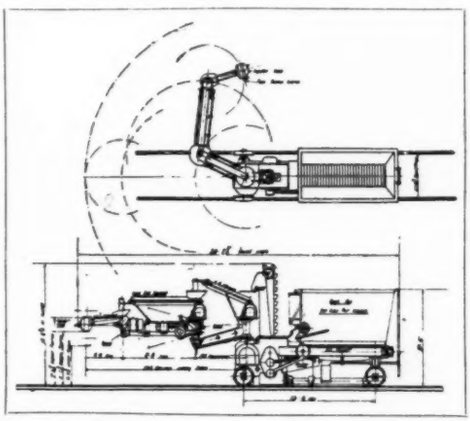


Fig. 3.—Shows the Outline Drawing of 17-ft. 6-in. Arm Motive Type Sandslinger operating in the Midlands of England.

For dealing with the mass production, the stationary type sand-slinger operating in conjunction with sand conveying, preparing and delivering machines on the one side, and mould conveying apparatus on the other, is producing results un-dreamt of by any other system of moulding.

In one installation the stationary machine is mounted on the floor on a fixed, definite position, while the stripping plates, etc., are arranged within the radius of the arm, which may be 9 ft. or 10 ft., sand being fed to the machine from overhead or other form of conveyor.

In a second installation a tractor, developed with a view to taking care of the quantity-production of castings, travels on a rack rail on the floor, and the moulding sand is placed in a long track in front of the machine, the depth of the sand being arranged in accordance with the type of mould being produced. A varying gear arrangement on the travel allows of the machine going forward at a speed conveniently to deal with the quantity of sand required. In other cases the stripping plate machines or other form of moulding machine are towed by this tractor type machine along the foundry floor. The moulding boxes which are left at the side of the machine can be dealt with by an overhead crane or by hand power, but where it is desirable jib cranes, as shown in Fig. 6, can be assembled on the sand-slinger to deal with loads up to 10 or 12 cwts. This makes the machine a very self-contained unit, and almost entirely independent of auxiliary gear in moulding.

The model tractor-type machine will handle 150/160 tons of sand per day, and when it is realised that the sand is cut, turned over repeatedly by the screw centring device, that it is elevated and dumped on to a high-speed riddle, and is fed from there on to the endless belt before it reaches the impeller, it will be appreciated that the sand is getting a very much better treatment or preparation than the average moulding sand does in a foundry floor. The very fact of the scrap being constantly removed from the sand is very helpful for getting it in good condition.

When moulding bath tubs, there exists one installation where three men are producing between 40 and 45 baths per day ready for metal. It is provided with four sand-slingers, there being provision for two lengths of track.

Fig. 5 shows the day's production of a tractor-type sand-slinger on 5 ft. soil pipes, two pipes per box, with a production of 600 pipes per day, or approximately 100 pipes per man per day. At the side of this row will be seen a part of a core-making machine. The cores are made by dropping sand from a height on a revolving bar and scraped off to the exact diameter. In this row three of these machines are functioning. Numerous installations of this type of core machine are operating in this country in conjunction with sand-throwing machines.

For the lay-out of a twin run bay of tractor-type machines, each of which tows an overhead bridge type crane and the patterns, and the sand lying in front of it. It permits of bringing the metal on overhead runway without the introduction of columns.

Where high finish work is called for, such as automobile cylinders and certain grades of light, fine ironwork, it has been found desirable thoroughly to riddle the sand periodically, and a machine built on a sand-slinger foundation has been developed with very great success. The average sand cutter merely aerates the sand, but this particular machine, travelling along the same track as the sand-slinger, cuts the sand, elevates and riddles it, the riddling being of a very thorough nature in a rotary drum. This machine is started up in front of the sand-slinger and is allowed to carry right along without any supervision other than casual examination. One such riddle will take care of the sand necessary for four tractor-type sand-slingers.

It will be readily seen how this particular model can be arranged to tackle large or small work. There are tractor-type machines in daily operation in this country producing pipes in moulding boxes 10 ft. long × 24 in. wide. On the other hand, five machines in the largest malleable ironfoundry in this country are producing moulds for castings of very small dimensions.

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* A Paper read before the Newcastle Branch of the Institute of British Foundrymen. Mr. Victor Stobie presiding. The author is General Manager of the Foundry Plant & Machinery Company.

The author's experience in discussing the tractor-type sand-slingers with users, and also with people who have investigated the process, makes him believe that the possibility of introducing a very orderly arrangement, together with the great economies obtained from the rapid production, has a great deal to do with the better quality of castings produced by the use of the sand-slinger. The thorough manner in which the whole installation is undertaken and the very fact that the operation is so apparent from the engineer's point of view as well as from the foundryman's, makes it an attraction to the engineer to exercise his ability to simplify handling, that produces results so entirely satisfactory.

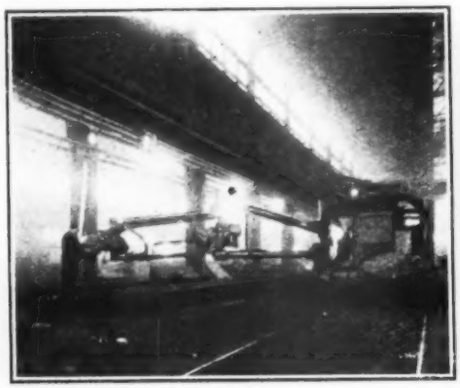

Fig. 4.—Shows 27-ft. 0-in. Locomotive Type Sandslinger in use in America.

Fig. 5.—Shows a Row of Soil Pipes, 2 Pipes per Box, 600 Pipes per Machine per Day.

Very briefly to sum up the tractor-type sand-slinger, one must realise that the moulding sand is in the foundry all the time that the moulding boxes are, only in two positions, viz., stacked at the side of the track empty, or ready for metal behind the machine. The transport, therefore, resolves itself into bringing liquid metal to the moulds and taking finished castings from the shop.

The greatest success of the sand-slinger in this country has been its application to jobbing castings, and the portable-type sand-slinger furnished the simplest application of the sand-slinging principle to the "one off" type of casting. With this machine, the moulding box found in the modern foundry to-day is entirely suited, while the patterns as delivered to the foundryman, if they can be moulded by hand moulding, can be equally well moulded by the sand-slinger. It is, of course, understood that no direct under-ramming can be undertaken, but the practice is to ram up to the level of the projection and under-tuck overhangs. Sloping projections can be undertaken after considerable experience, but one would do well to appreciate that where projections stand out from a pattern these should be dealt with by hand-tucking locally, the sand-slinger ramming being used to fill the mould up to the level convenient for such operation.

With this machine small or very large moulds can be produced; the machine, being entirely independent of any foundation other than its own massive cast-iron bed, is transported from site to site by overhead crane, or in some instances it is mounted on wheels and pushed about on a level rail up and down the foundry.

With the introduction of the portable machine, it was necessary to increase the flexibility of the ramming, and a heavier type of motor has been installed; and where direct current is available two speeds are fitted, usually approximately 1,500 r.p.m. and 1,800 r.p.m. With the harder ramming moulds can be produced capable of withstanding the very heaviest rush of metal.

Fig. 1 shows a mould rammed in the floor, the ramming being done by the sand-slinger exclusively with, perhaps, the exception of some slight overhang patches on the inside. After the hole had been prepared and cinder bottom placed in, the sand bottom was rammed by the sand-slinger, strickled off, the fitting strips placed in position, pattern assembled thereon, and the mould rammed right up. The drawbacks were also rammed in the same way, as also the core, together with the top part, which completed the mould. A very conservative estimate of the economy obtained on this particular job was kindly supplied to the author by the users.

The ramming time with the sand-slinger was 15 man-hours; this included all the ramming necessary, besides the actual sand-slinger. The same bed has been made many times before, and the average time where hand ramming, assisted by pneumatic ramming, was used, worked out at 90 man-hours.

The casting was a 15-ton engine bed-plate shown in Fig. 1. The casting was perfect, and the economy was such as to justify the firm in ordering a further three sand-slingers of the same type. In this country some castings are still made in loam which might be made to profit by sand-moulding with slingers.

It would be noticed that with the portable-type sand-slinger, the sand was shovelled into a hopper at the boot of the elevator. Where a bigger production was required a special hopper was built with a slat bottom to function in conjunction with the portable machine. This development suggested a still further advancement, and caused the creation of the motive-type sand-slinger, which is probably the greatest advance that has been made in foundry practice up to date.

The motive-type machine shown in Fig. 3 has a radius of 17 ft. 6 in., and is in operation in the Midlands of England. The tank has a capacity of approximately 10 tons of sand, the bottom of the tank being a moving slat which gradually feeds a pre-arranged quantity of sand into a riddle from which it is elevated to the first of three endless belts. The first arm pivots like a drilling machine, and can be locked at any position within its radius. The other two arms are of a sensitive ball-bearing type, and the operator pulls them around when operating the head.

This machine travels on a standard rail track at approximately crane speed up and down the foundry, and can deal with moulding boxes in two bays. The advantage of this machine where a large quantity of work is being produced will be obvious in so far as it can be used to ram a part of a job and economically move rapidly to another mould where part of it can be rammed, also allowing the moulders to continue with their part of the work.

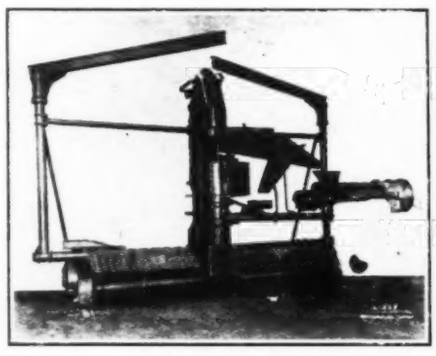

Fig. 6.—Shows the Latest Model Tractor Type Sandslinger, with Jib Cranes.

The motive-type sand-slinger has an arrangement whereby the head can be raised from approximately 3 ft. 6 in. to 7 ft. The advantage of this arrangement will be apparent when the large range of work dealt with in the average heavy jobbing foundry is taken into consideration.

The moulding sand for this type of machine is prepared at a fixed position in the foundry and is elevated to a tank container under which the motive-type sand-slinger runs to have the sand deposited from the container into its tank. The sand-preparation plant is working continuously, and when it is realised that to keep the motive-type sand-slinger in normal full production 20 to 30 tons per hour of sand will be necessary, considerable care must be taken in arranging that the sand preparation plant is adequate. With this machine the order and arrangement of the foundry becomes simple and almost elementary.

The moulds are rammed alongside of the track, and in one instance a moulder with some labourer assistance sets the patterns and moulding boards, places the strips, loose pieces, and fits the moulding box. The sand-slinger then comes along and rams up the mould. In some cases it may be that other parts of the pattern have to be fitted or that other parts of the moulding box have to be assembled. Meantime the sand-slinger is employed elsewhere. After the moulds have been completed they are rolled over so as to be finished alongside of where they were moulded, and in this respect do not in any way interfere with the sand-slinger arrangement. It is possible that where green sand moulds are made they will be poured on the same site, but for dry sand moulds they will very likely be poured at a pouring position conveniently situated to the stoves. The entire moulds after pouring are removed to a fixed shake-out position, so that the moulding boxes can be stacked conveniently at one area, the moulding sand be treated all together at one plant, and in a very short time a system is developed which keeps the foundry floor at a decent level and removes the too common fault of bings of sand and scattered boxes utilising about half of the available moulding space.

The very rapid ramming by the sand-slinger necessitates an equally rapid turnover of the moulds, and the moulders appear to appreciate the great advantage to them of being employed at really skilled and artistic work in finishing the moulds. The sand-slinger may truly be said to remove one of the greatest nightmares that a moulder can experience, viz., the ramming of a very big job.

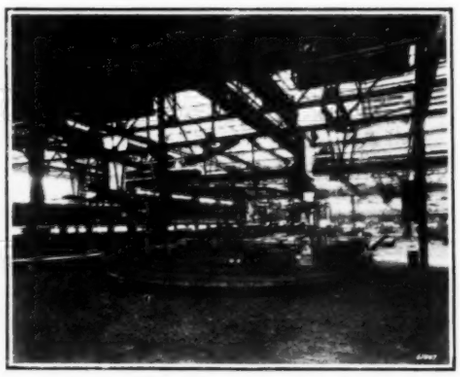

Fig. 7.—Shows a Horse Shoe Gravity Conveyor and Sandslinger Installation, being one of five in the same building.

Each different foundry has to face its own problem as to the application of the sand-slinging system, and it is in this respect that many foundrymen find the greatest difficulty in settling down to introducing the new schemes. It is easy to lay out an ideal foundry to deal with modern production, but it is sometimes very difficult to

adapt the existing foundry to get anything like adequate return from the machine installed.

In the average moulding shop, if it were possible thoroughly to analyse the functions, the transport of materials would show as the greatest of all costs, and with the introduction of a method which will more rapidly deal with one section of the production, the very first difficulty that will arise will be the out-of-balance caused by the new condition. The introduction of sand-slingers to foundries calls immediately for the introduction of a very considerable proportion of extra sand. The author has yet to find a foundryman who takes this statement with sufficient seriousness until he is up against it. One would expect that by merely turning over the moulds quicker they would be shaken out quicker, but the fact remains that the very rapid call for sand places the normal sand supply at a very serious disadvantage. For instance, in the ramming of a 7-ton bed-plate, a large electrical engineering firm were able to do the ramming in approximately one hour as compared with 60 hours previously employed on the job. Regarded from any angle it will be realised that the sand required over 60 hours previously had to be forthcoming in one hour. Again, there is the case of a firm in Scotland, where only six moulders are employed, and which, when using a portable sand-slinger, made an engine trunk of about 8½ tons, the ramming up of the mould being performed in 29 minutes. The previous week

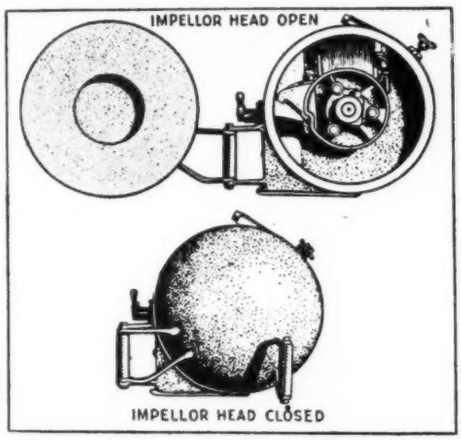

Fig. 8.—Shows the Impeller Head, Closed and Open.

8 hours had been necessary for the same work when hand ramming was used.

A peculiar fact which the writer thinks may pass unrecognised is that the sand-slinger will ram about 20 per cent. more sand into a deep mould than is usual by hand ramming, thus showing the density of the ram.

Fig. 4 shows a machine which has been developed in America, but one which is not likely to find a place in foundries in this country. This is the locomotive type machine with a 27-ft. arm, at the works of the Allis Chalmers Company, Milwaukee, U.S.A. This machine is provided with a means of lifting the sand from the floor, riddling it through a very fine riddle, all the sand passing through magnetic separators before being elevated to the sand-conveying belts. Castings up to 90 tons are made on slingers at this plant.

Mass Production by the Sand-Slinger in America.

Fig. 7 shows three horse-shoe arrangements in an aluminium foundry, there being altogether five similar units in this particular shop. The introduction of mass production on the sand-slinger brought forward many engineering problems; one of these was the best method of bringing the moulds and the sand-slinger head together. The practice naturally adopted now in America is to use a turntable built up of strip iron grating, so that the sand spilled from the moulding box will fall through the grating; this is dealt with by a collector and belt underneath the grating, where it is returned to the sand hopper.

The introduction of a new process very often calls for the criticism that where speed is obtained the benefit may be lost by reduction in quality. The experience of the automobile industry in the United States, as it is also to-day in this country, is demonstrating that the sand-slinger can produce castings superior to hand-ram, jar-ram, or squeeze castings much quicker and under conditions of great economy, the greatest of these perhaps being the fact that the castings are produced in green sand moulds, a thing which has not been done in this country or in America on jar-ramming, squeeze or hand-rammed moulds. This advantage is certainly due to the more open nature of the ramming together with the density giving the ability of the sand to stand up to the wash. Interesting figures in this connection have been published by Mr. Webber, the Wilson Foundry Company, Pontiac, Michigan, reproduced in Fig. 9, from which it appears that in the year 1905 the space occupied by gates and sprues 27.25, now takes care of all the loss, and that the good castings have increased from 46¼ per cent. to approximately 73¾ per cent. The most conspicuous economy is that referring to scrap, which in 1905 amounted to 9.21 per cent., while in the sand-slinger manufacture the scrap amounted to 2.36 per cent. The returns from the machine shop in 1905 represented 4.27 per cent., while with green sand castings made on the sand-slinger the return is under 2 per cent. Obviously, the limit of accuracy called for in 1924 as compared with that called for in 1905 would probably increase enormously the scrap and the returns from the machine shop of the 1905 castings. It should also be borne in mind that the castings produced to-day are of lighter section, and of much more complicated design, as they call for many extras which were not even thought of in the 1905 production.

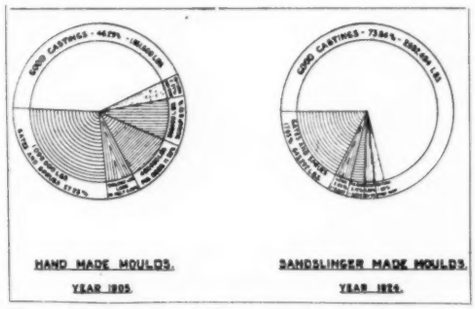

Fig. 9.—Shows the Chart referred to at the end of the Paper.

Evidence is very strong to show that a consistent economy can be obtained on the weight of castings; that castings are being produced nearer to pattern size on the sand-slinger; and where large surface castings such as tank plates are taken into consideration, it has been stated that economies equal to 8 per cent. have been obtained, and that the castings are so uniform in weight that to weigh one is to obtain approximately the average throughout the batch.

Another firm using the sand-slinger on large cast-iron boiler sections report an economy of over 4 per cent. in weight, a very considerable reduction in scrap, and a labour economy indicating that the machine would be written off within one year of its purchase, which justified further orders being placed for duplicate machines. A Newcastle district user has given publicity to a statement that after two years' experience he had been surprised at the almost trivial nature of the repairs and renewals. Another Tyneside user has also expressed his surprise at the minimum expense occasioned in maintaining sand-slingers of two different types.

The author is confident that in the near future great steps will be taken towards the ramming of moulds by this system, and that with the very apparent shortage of moulders in some districts, the tendency will gradually be to use moulders intelligently for their craftsmanship, and relieve them of the burdensome and laborious task of ramming sand.

[The author then showed a film of the use of sand-slingers in U.S.A.]

The rapid growth of American foundries, together with the embargo on immigrants, has made the American foundryman very dependent on use of labour-saving plant, so that his valuable skilled labour can be used to exercise that skill to the greatest advantage.

The lack of apprentices in moulding shops will bring about somewhat similar conditions in this country, and even to-day, if the trade became moderately busy, the scramble for moulders would be tragic.

Book Review.

Tin and the Tin Industry, by A. H. Mundey. Published by Sir Isaac Pitman & Sons, Limited, Parker Street, Kingsway, London, W.C.2. Price 3s. net.

The publication of this excellent little book is particularly welcome at the moment, as efforts are being made to interest the man in the street in this particular metal. This laudable movement is associated with an endeavour to stabilise the price of tin, at maybe a figure which will be sufficient to cover adequately the cost of its production in Cornwall.

The book, although quite elementary in character, can be taken as being essentially authoritative, as its author is one of the foremost metallurgists in Great Britain, who for the last decade has personally supervised the manufacture of articles of commerce made largely from tin. The book is divided into eleven chapters and is well illustrated and indexed. It is totally free from padding, is of considerable literary merit (a factor not often encountered in a technical book), and considering its size is very comprehensive. Chapter I might have a more apt caption than "Early History of Tin," as less than a page and a half is devoted to that particular subject. It is a comprehensive chapter, dealing with its properties, occurrence, mining, and the preparation of the pure metal.

Chapter II reveals the field which metallurgists explore in the hope of finding new alloys or throwing light on the behaviour of existing ones. Bronze is detailed next, and space is given to gun-metal, coinage bronze, bell-metal, phosphor copper and phosphor tin. These alloys are followed by the tin-antimony-lead group, and include antifriction alloys, printers' type metal, pewter, solders and special alloys.

Chapter IV details the story of the various white metals, and Chapter V that exclusive branch of the foundry industry—printers' alloys. Subsequently, solders, tinplate and pewter receive detailed treatment, whilst later chapters are devoted to tin foil, die casting (obviously written by a master of the subject), and assaying.

We strongly recommend our readers to add this book to their libraries as being an authoritative introduction to the study of tin products.

Patent Specifications Accepted.

The following list of Patent Specifications Accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications can be obtained from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

29,869. Smith, W. Joining together of metal surfaces. November 25, 1926. (Cognate Application, 23,036/27.) 285,995.

31,504. Moseley, C. Metal-rolling machines. December 13, 1926. 286,025.

288. Gibson, W., and Pocock, E. J. Fire-bars for furnaces. January 5, 1927. 286,039.

3,980. Aktieselskapet Norsk Staal (Elektrisk-Gas-Reduktion), and Edwin, E. Production of synthetic pig-iron. February 12, 1927. 286,067.

4,434. Bennis, A. W. Mechanical stokers for furnaces. February 17, 1927. 286,074.

5,580. Dittmar, E. Coal-dust boiler-furnace. February 28, 1927. 286,084.

7,344. Cockin, E. Boiler furnaces employing travelling firegrates. March 16, 1927. 286,098.

9,187. Vidal, A. E. (Littell, N.). Foundry-moulding apparatus. April 4, 1927. 286,109.

10,459. Babcock & Wilcox, Limited (Babcock & Wilcox Company). Method of spraying liquids. April 19, 1927. 286,114.

The Structural Composition of Cast Iron by Weight and Volume.

A METHOD OF SELECTIVELY APPORTIONING THE ELEMENTS AS GIVEN BY THE ULTIMATE ANALYSIS.

By W. E. Dennison.

Most persons connected with iron-founding are familiar with the usual form in which the analysis of a casting or test bar is given, but comparatively few are conversant with an analysis in its structural form. The usual form is that of the ultimate analysis which gives the percentage of silicon, graphitic and combined carbons, phosphorus, sulphur, manganese and iron. The last is generally computed by difference and therefore includes the aggregate of the small percentages of other elements, such as copper, arsenic, vanadium, nickel and chromium, which sometimes occur in minute quantities in ordinary commercial pig-iron. These quantities are so small that for technical purposes they can usually be ignored. Of course, in the case of special cast irons containing an appreciable amount of one or more of these special elements the percentage of each is recorded as a separate item and is not included in the "iron by difference."

Persons with a superficial knowledge of the constitution of cast iron refer to the various elements as though each existed in the elemental state. Undoubtedly such members of the foundry and engineering world are to be excused, as the ultimate or elemental analysis is practically the only form in which the composition of cast iron is recorded. What would be the impression gained by the uninformed if the chemist recorded a sample of water as containing X grains of calcium per gallon, instead of selectively joining up the metal with the available acid radicles? Or, similarly, what would the ultimate analysis of sand convey to the mind? We refer to silica instead of silicon when speaking of sand, and it is just as necessary to refer to silicide of iron instead of silicon when considering the composition of a cast iron. To speak of so much per cent. phosphorus when the binary phosphide eutectic is 9.8 times as much is really misleading to the comparative layman.

As at present given, the analysis has really only an index or relative value, and the author herewith outlines in detail, for the benefit of the great number of foundrymen and other interested persons not conversant with the subject, a method of selectively computing, from the usual ultimate or elemental analysis, the structural composition both by weight and volume.

Considering that only the graphitic carbon is present as stated in the ultimate analysis, and that the other elements are present in various combinations, it is clear that an ultimate analysis is nothing like so comprehensive as a proximate structural one, particularly if the latter gives the percentage by volume as well as by weight. It is now generally agreed as to the common combinations which occur in a normally-cooled commercial grey iron. Therefore, although the method and sequence of apportioning the elements are somewhat of an arbitrary character, it will be agreed that the structural results obtained are not far from the truth and that they present the composition in a form which is capable of visualisation.

Of course, it goes without saying that calculated volumetric structural analyses do not take the place of microscopic examinations, but that such results considered in combination with such examinations, or even in lieu of them, give extremely valuable indications.

How the Elements Exist.

Silicon exists as the silicide of iron, FeSi, which is in solution in the ferritic matrix.

Graphite exists as free elemental carbon in various sized flakes, plates or nodules, which, by breaking up the metallic continuity, seriously influence the physical properties of the metal. It is generally considered that the graphite existing as curly plates has separated at a temperature near the melting range when the metal was mobile. That which is formed from the decomposition of solid cementite has a more pulverulent form, being larger but similar in shape to the nodules of annealed white iron. Further, graphite is also found associated with ferrite in such a way that it has been inferred that it is eutectic formed.

Again, it has been suggested that its refractoriness affects its ready solubility in iron, and that this characteristic allows it to pass through a melting process without undergoing solution, such undissolved graphite forming nuclei for the formation of large plates or nodules to the detriment of the physical characteristics of the resultant castings. The degree of superheat is also a factor which decides the presence or otherwise of undissolved graphite.

From this it will be realised that the various characteristics of graphite offer the greatest drawback to the value of a structural analysis when considered without the aid of a microscopic examination. However, even in the absence of microphotographs, a knowledge of the volumetric structure of a cast iron is quite valuable, for an intelligent foundryman can form a fairly accurate opinion of the character of the graphite by a microscopic or visual examination of the fracture.

Carbon in the combined state is present as carbide of iron or cementite, Fe_3C. This cementite occurs with alternate layers of ferrite to form pearlite, which is the iron-iron carbide eutectoid. Pearlite corresponds to 0.89 per cent. carbon or (Fe_3C + 21Fe). Thus it is a conglomerate containing 86.72 per cent. of ferrite and 13.28 per cent. of cementite, which is equivalent to 6.53 parts and 1 part respectively.

Pearlite usually occurs in the lamellar form, but when the transformation of martensite has been hastened, as it is claimed may occur with centrifugal spun iron, its form is more granular and is sometimes termed sorbitic. Here again, without the aid of a microscopic analysis, the foundryman may use his judgment from his knowledge of the nature and method of production of the casting.

Considerable interest is now being taken in cast irons in which nearly all of the ferrite is pearlitic. To obtain this condition without the presence of free cementite is a matter of very exact composition and cooling control. When there is an excess of cementite over the amount necessary to form pearlite with the available ferrite, the castings are commercially unmachineable. For chill castings, however, this phenomenon is utilised, and it is therefore necessary to consider the free cementite in the study of the structural analysis.

Phosphorus occurs as phosphide of iron, Fe_3P. A binary eutectic iron-iron phosphide and a ternary iron-carbon-phosphide eutectic are known. In grey irons the silicon causes the breakdown of the carbide phosphide eutectic, and the eutectic of iron and phosphide is found. This eutectic has been shown to consist of 61 per cent. Fe_3P and 39 per cent. of the saturated solution of Fe_3P in iron. Thus it contains 10.2 per cent. phosphorus.

Sulphur exists as manganese and iron sulphides, but it is generally agreed that manganese has the stronger chemical affinity for sulphur, and accordingly that where the percentage of manganese is in sufficiently high ratio to the sulphur content that the latter is present as MnS. The theoretical ratio is 1.73 parts of manganese to 1 part of sulphur, but, practically, a ratio of about 4 to 1 is necessary in order to ensure the sulphur being completely present in combination with Mn as manganese sulphide. This ratio will be used in our computations of the structural volumetric analysis, and any excess sulphur will be considered as sulphide of iron. Very few commercial irons contain less manganese than the ratio mentioned, but as sulphide of iron is known to have a very much more deleterious influence on cast iron than manganese sulphide, the FeS must be separately recorded when necessary.

Manganese occurs as sulphide and carbide. Any amount that has not been apportioned to the sulphur may be considered as being present as manganese carbide, Mn_3C, which is regarded as part of the cementite.

Iron is present in combination with the silicon, carbon, phosphorus, sulphur and manganese in the various combinations already mentioned. That which is in excess of these amounts forms the ferritic matrix, and for the purpose of computing a structural analysis may be designated "free ferrite."

Procedure of Computation.

The first step in the computation of the structural composition is the calculation of the proximate chemical analysis from the ultimate.

Table I.—*Factors necessary for Computing the Volumetric Structural Analysis from the Analysis in its Usual Ultimate Form.*

Element.	Atomic Weight.	Compound.	Molecular Weight.	Factors.
Silicon, Si ..	28.30	Iron Silicide, FeSi	84.14	Si to FeSi 2.973 (3.0)
Carbon, C ..	12.00	,, Carbide, Fe_3C	179.52	C ,, Fe_3C 14.960 (15.0)
Phosphorus, P ..	31.04	,, Phosphide, Fe_3P ..	198.56	P ,, Fe_3P 6.397
Sulphur, S ..	32.07	,, Sulphide, FeS	87.91	S ,, FeS 2.741
Manganese, Mn	54.93	Manganese Sulphide, MnS ..	87.00	S ,, MnS 2.713
Iron, Fe ..	55.84			MnS ,, Mn 0.631
				Mn ,, Mn_3C 1.073
				Mn_3C ,, C 0.068

For this operation the factors given in Table I are necessary.

As a concrete example it will be interesting to take a cast iron of the following composition:—Gr.C, 2.87; C.C, 0.62; Si, 1.88; Mn, 0.50; S, 0.12; and P, 0.64 per cent.

The procedure is as follows:—Calculate Si to FeSi; P to Fe_3P; S to MnS; remainder of Mn to Mn_3C, and remainder of combined C. to Fe_3C. Graphite remains unchanged in the proximate analysis, whilst the sum of the above items taken from 100 gives the ferrite.

Thus the following figures are produced:—

Chemical Analysis.

Ultimate.		Proximate.	
Si	1.88	FeSi	5.64
Gr.C	2.87	Gr.C	2.87
C.C	0.62	Fe_3C	8.98
P	0.64	Fe_3P	4.09
S	0.12	MnS	0.33
Mn	0.50	Mn_3C	0.31
Fe	93.37	Fe	77.78
	100.00		100.00

The next procedure is to add together the manganese and iron carbides to obtain the percentage of cementite. The ultimate structural analysis is then obtained from the proximate chemical composition:—

Proximate Chemical Analysis.		Ultimate Structural Analysis.	
FeSi	5.64	Iron Silicide ..	5.64
Gr.C	2.87	Total Ferrite ..	77.78
Fe_3C	8.98	Cementite ..	9.29
Fe_3P	4.09	Mn Sulphide ..	0.33
MnS	0.33	Iron Phosphide	4.09
Mn_3C	0.31	Graphite ..	2.87
Fe	77.78		
	100.00		100.00

Factors additional to those given in Table I are required to compute the proximate structural analysis from the ultimate structural composition. These are: Cementite to pearlite × 7.53, and iron phosphide to iron and phosphide eutectic × 1.50. Thus in this specific case one obtains:—

Structural Analysis.

Ultimate.		Proximate.		
Iron Silicide	5.64	Iron Silicide	5.64	20.72 Silico Ferrite
Total Ferrite	77.78	Free Ferrite	15.08	
Cementite	9.29	Pearlitic Ferrite	60.66	69.95 Pearlite
Mn Sulphide	0.33	Cementite	9.29	
Iron Phosphide	4.09	Mn Sulphide	0.33	
Graphite	2.87	Phosphide Eutectic	6.13	
		Graphite	2.87	
	100.00		100.00	

Volumetric Considerations

The next thing to consider is the specific gravities of the various constituents. These are given in Table II, and are mean values as determined by different authorities.

Table II.—*Specific Gravities of the Constituents in Cast Iron.*

Constituent.	Specific Gravity.
Iron Silicide	6.2
Ferrite	7.85
Pearlite	7.8
Cementite	7.7
Manganese Sulphide	4.0
Phosphide Eutectic	7.2
Graphite	2.3

To obtain the structural composition of cast iron by volume from the composition by weight it is necessary to divide the weight percentages by the specific gravities of the constituents, and again divide the individual results × 100 by the total of the quotients found. This total, divided into 100, gives the mean specific gravity of the cast iron.

Proximate Structural Analysis.

	By Weight.			By Volume. Per cent.
Iron Silicide	5.64 ÷ 6.2	=	0.91	6.51
Free Ferrite	15.08 ÷ 7.85	=	1.92	13.74
Pearlite	69.95 ÷ 7.8	=	8.97	64.16
Manganese Sulphide	0.33 ÷ 4.0	=	0.08	0.57
Graphite	2.87 ÷ 2.3	=	1.25	8.94
Phosphide Eutectic	6.13 ÷ 7.2	=	0.85	6.08
	100.00		13.98	100.00

The calculated mean specific gravity is therefore 100 ÷ 13.98 = 7.15.

Table III has been drawn up on the foregoing basis, and includes typical commercial pig-irons and compositions suitable for various types of castings.

A study of the table is extremely interesting. The term cast iron is proved to cover a very extensive range of alloys. It is interesting to analyse the results and record the minimum and maximum percentages of the various constituents. Here it can be said that the compositions given are just within the extremes found in commercial irons but exclude special ferro-alloys.

When it is realised that an ordinary commercial grey iron may contain graphite to an extent greater than one-tenth of its volume, the physical limitations may be better comprehended. Even the most superior example of cast iron, as we know it to-day, contains one-fifteenth of graphite by volume.

Structural Diagrams.

The six diagrams of selected examples taken from Table III are interesting in showing at a glance the comparative compositions by volume of typical irons. For instance, a comparison of the high-grade pearlitic casting with black-heart malleable shows the main difference to be in the matrix, which in the first case is pearlitic, and in the second case ferritic, both being quantitatively about the same.

Percentage Limits.

	By Weight.	By Volume.
Iron Silicide	1.80 to 9.00	2.23 to 10.24
Free Ferrite	None ,, 92.96	None ,, 86.47
Pearlite	None ,, 89.83	None ,, 84.59
Free Cementite	None ,, 42.88	None ,, 42.67
Mn. and Fe Sulphides	0.05 ,, 0.40	0.09 ,, 0.76
Phosphide Eutectic	0.49 ,, 15.19	0.48 ,, 14.95
Graphite	None ,, 3.55	None ,, 10.90
Specific Gravity Limits	7.06 to 7.66.	
or	100 to 108.5 per cent.	

The diagram of the light ornamental casting shows the extent of the phosphide eutectic, which is present chiefly in order to produce fluidity.

The diagram of the white-iron sample shows the extent to which free cementite can occur when graphitisation is completely prevented. This

(*Continued on p.* 230.)

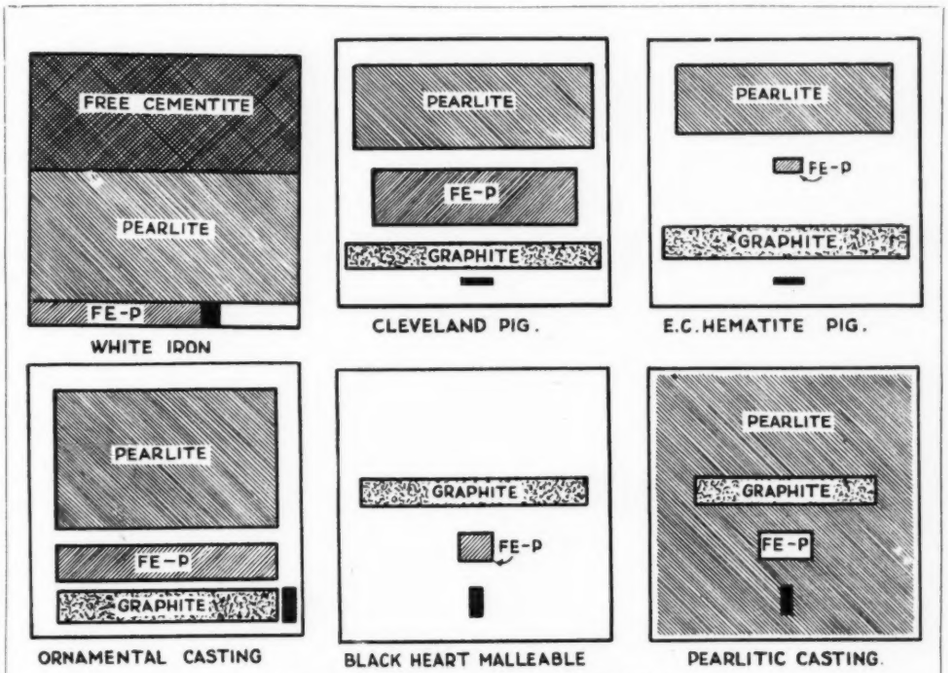

Fig. I—Black = MnS; White = Silico-Ferrite.

Table III.—*Structural and Volumetric Composition of Various Cast Irons.*

Description.	Ultimate Chemical Analysis.							Proximate Structural Analysis by Weight.								Proximate Structural Analysis by Volume.								Calculated Specific Gravity.
	Si.	Gr.	C.C.	P.	S.	Mn.	Fe.	Iron Silicide.	Free Ferrite.	Pearlite.	Manganese Sulphide.	Phosphide Eutectic.	Graphite.	Iron Sulphide.	Free Cementite.	Iron Silicide.	Free Ferrite.	Pearlite.	Manganese Sulphide.	Phosphide Eutectic.	Graphite.	Iron Sulphide	Free Cementite.	
No. 1 E. C. Hematite	3.00	3.55	0.20	0.05	0.02	1.20	91.98	9.00	64.47	22.44	0.05	0.49	3.55			10.24	57.98	20.31	0.09	0.48	10.20			7.06
No. 4 Cleveland	2.25	3.03	0.27	1.55	0.04	0.65	92.21	6.75	44.27	30.65	0.11	15.19	3.03			7.72	39.95	27.85	0.20	14.95	9.33			7.08
No. 3 Lincs.	1.76	2.60	0.60	1.22	0.025	1.86	91.935	5.28	12.32	67.77	0.07	11.96	2.60			6.12	11.27	62.43	0.13	11.93	8.12			7.18
American Malleable (Pig)	2.28	3.47	0.49	0.12	0.024	0.81	92.806	6.84	33.63	54.81	0.07	1.18	3.47			7.82	30.37	49.82	0.13	1.16	10.70			7.09
American Bessemer	2.28	3.40	0.43	0.07	0.025	0.70	93.095	6.84	40.73	48.27	0.07	0.69	3.40			7.84	36.87	43.97	0.13	0.68	10.51			7.11
Black Heart Malleable	1.00	2.65	—	0.12	0.075	0.26	95.895	3.00	92.96	None	0.18	1.18	2.65	0.03		3.53	86.47	None	0.33	1.20	8.41	0.06		7.30
Pearlitic casting*	1.10	2.10	0.80	0.20	0.07	0.75	94.98	3.30	2.62	89.83	0.19	1.96	2.10			3.91	2.45	84.59	0.35	2.00	6.70			7.34
Auto. cylinder	1.80	2.50	0.70	0.32	0.10	0.80	93.78	5.40	10.15	78.54	0.27	3.14	2.50			6.30	9.35	72.84	0.49	3.15	7.87			7.23
Ingot Moulds	1.25	2.65	0.65	0.10	0.12	1.00	94.23	3.75	19.25	73.04	0.33	0.98	2.65			4.40	17.78	67.89	0.60	0.98	8.35			7.25
Large Gears	1.50	2.50	0.72	0.30	0.11	0.90	93.97	4.50	8.36	81.40	0.30	2.94	2.50			5.26	7.72	75.64	0.54	2.96	7.88			7.25
Ornamental Castings	2.40	3.09	0.40	1.05	0.10	0.55	92.41	7.20	34.27	44.88	0.27	10.29	3.09			8.22	30.92	40.75	0.48	10.12	9.51			7.08
White Iron Castings	0.60	—	3.30	0.50	0.15	0.52	94.93	1.80	None	50.02	0.35	4.90	None	0.05	42.88	2.23	None	49.13	0.67	5.21	None	0.09	42.67	7.66
Mottled Castings	0.92	1.50	1.80	0.22	0.13	0.36	95.07	2.76	None	76.37	0.24	2.16	1.50	0.11	16.86	3.30	None	72.71	0.45	2.23	4.84	0.21	16.26	7.43

* As most grey irons are to a certain extent pearlitic, the designation "pearlitic" as applied to a cast iron is somewhat misleading. In recent nomenclature, however, it is intended to imply that the practical minimum of free ferrite is present. Ordinarily this condition is obtained in green or dry sand moulds by employing a suitable silicon content which varies inversely with the section of the casting. It is claimed, however, for certain modern processes, which employ hot moulds and a low silicon content which would ordinarily give castings with a white fracture, that, by virtue of the prolonged period of cooling through the critical range at which the maximum amount of pearlite formation occurs, the structure is, as nearly possible as the other constituents permit, completely pearlitic. What is more, the pearlitic structure is said to obtain throughout all sections—*i.e.*, thicknesses. This latter feature is undoubtedly a most valuable characteristic.

High-Grade Cast Iron.*

By J. E. Hurst.

In these days, when so much intensive research is being carried out in so many directions by individual metallurgists in all countries of the world, it is very desirable to review the progress made from time to time. Within the confines of a short Paper such review must of necessity be of a broad and general nature—and there can be no doubt that such a review in attempting to provide an orderly conception of the developments is strictly scientific and justifiable. In pursuing this subject it is essential to define what is meant by high-grade cast iron. The definition of this will depend upon the purpose for which the cast iron is intended, for it is clear that the qualities and properties which justify the application of this title to material intended for internal combustion engine cylinders are not necessarily the same in material intended for the manufacture of kettles. It is possible to examine, however, all the various uses to which cast iron is put, and from a consideration of the various properties and qualities required, to define high-grade cast iron as that in which either several or all of the properties listed below are obtained in the highest degree:—(1) Soundness; (2) machinability; (3) ultimate strength; (4) resistance to impact; (5) resistance to wear; and (6) resistance to volume changes and distortion under heat influence.

Table I.—*Chemical Composition of certain High Tensile Strength Cast Irons.*

No.	C.C.	Gr.	Tot. C.	Si.	Mn.	S.	P.	Tensile.	Authority.
	%	%	%	%	%	%	%	Tons per sq. in.	
1	0.50	1.89	2.39	1.91	0.40	0 14	0.45	16.7	Cameron.
2	0.80	2.42	3.22	2.35	0.53	0.06	0.64	20.0	Cameron.
3	—	—	2.62	2.09	0.96	0.11	0.15	26.3	Emmel.
4	0.20	2.40	2.60	2.8	0.60	0.15	0.50	19.2	Swinden.
5	1.78	1.20	2.98	1.95	0.20	0.05	0.05	19.6	Hatfield.
6	2.25	—	2.25	0.40	0.93	0.01	0.01	22.0	Carpenter.
7	—	—	2.90	1.75	0.50	0.05	—	31.7	Keller.
8	0.70	2.60	3.30	1.20	0.70	0.08	0.07	17.7	Milton.
9	0.84	2.30	3.14	1.27	0.44	0.11	0.85	17.9	Milton.

Of all these properties or qualities by far the most important is that of soundness. It is obvious that whatever the other properties may be, unless the castings are sound they are generally valueless and there are doubtless still many cases where engineers content themselves with admittedly inferior material from various standpoints on the grounds of certainty as to soundness.

It is a matter of considerable astonishment how difficult it is to make even a plain cylindrical casting, to finish without any trace of unsoundness or surface blemishes, particularly when the casting is required to be machined all over. The difficulty in the production of castings perfectly and absolutely sound is a general one—and is probably less in cast iron than in any other industrial alloy.

Table II.

	T.C.	Si.	Mn.	S.	P.	Tensile.
	%	%	%	%	%	Tons per sq. in.
Turner ..	2.21	1.37	—	0.05	0.30	14.04
Turner ..	2.18	1.96	0.60	0.03	0.28	15.70
Refined Pig-iron	3.2	0.8—1.0	1.0	0.08	0.4	17.00
Refined pig-iron	3.2	1.0	1.0	0.08	0.1	18 to 20

Unsoundness can be divided into two types, the first arising from the inclusion of slag, dirt, washings from the surface of the mould which usually become entrapped in the re-entrant angles and intricacies of the casting. The remedy for this type of unsoundness is generally a matter of the method of moulding, ramming, disposition of gates, and risers. The second type of unsoundness takes the form of internal porosity or sponginess and blowholes. This is an inherent defect to which castings are liable, and as such is the most important difficulty which confronts the founder in the successful production of castings.

The modern view as to the cause of such inherent unsoundness, and the view which is rapidly gaining ground is that it is to be ultimately ascribed to the manner in which the molten metal solidifies in the mould. The older view ascribing unsoundness, particularly that due to blowholes, to the gases evolved from the mould as a result of contact with the hot metal, is steadily being superseded. It has always been difficult to understand, except in the very obvious case when molten metal is poured into an exceptionally wet mould, how the mould gases could penetrate into the interior of the casting through the solid walls which must be formed almost instantaneously after the metal is introduced into the mould.

This difficulty has been felt by foundry metallurgists for many years—and it is not really many years ago that the only explanation of difficult cases of unsoundness where the mould was obviously not to blame, was high sulphur content.

The modern views on the question are more readily understandable when the true character of liquid cast iron is realised. Liquid cast is really very like soda water, and contains a large quantity of dissolved gases. Even in the solid state it is quite common to find cast iron containing three times its own volume of dissolved gases, which incidentally consist of hydrogen, nitrogen and the oxides of carbon. Exactly as in other liquids the solubility of these gases is greater in the liquid state than in the solid state, and furthermore, the solubility is lessened with increasing temperature. The presence of these dissolved gases is an important factor, and they are undoubtedly responsible for by far the greater majority of cases of unsoundness in castings.

The behaviour of the liquid metal on cooling from the molten state in special respect of the dissolved gases can be followed clearly by bearing the above facts in mind. The liquid metal at the time of casting may or may not be saturated with dissolved gases. As the temperature falls the solubility of the gases increases, and the amount of gas in solution becomes considerably less than the saturation value, until the casting commences to solidify. At this point, owing to the marked decrease in solubility accompanying the change from the liquid to the solid state, the gases are evolved from the solidifying portion of the mass and become more and more concentrated in the remaining liquid portion. As solidification proceeds the gases concentrate in the last remaining portion of the liquid metal, and this contains the whole of the dissolved gases in excess of the difference in solubility between the liquid and the solid state. It may be that the concentration of these gases in the manner indicated results in the saturation value being reached in the last portion of liquid metal, in which event the excess gases will be evolved and blowholes and unsoundness result.

The presence of large quantities of dissolved gases in cast iron and their ability to make their presence felt can be demonstrated very clearly in the many experiences met with in the production of castings in metal moulds, under which circumstances there can be no doubt about the absence of mould gases.

Mention of the soda-water analogy raises the interesting point of the liberation of the dissolved gases by excessive agitation of the cast iron. There can be no doubt about this. Under certain circumstances excessive agitation is imparted to the molten metal in the centrifugal process, and this is frequently accompanied by the formation of what appears, when cold, to be a spongy mass which is undoubtedly formed in a similar manner to the froth on aerated liquids. It is quite conceivable that the molten metal can be introduced into sand moulds under such circumstances as to cause agitation—and this same formation may be responsible for some of the cases of unsoundness which are observed.

The tendency towards the segregation of dissolved gases into the interior of the castings as a cause of unsoundness is added to by the effects of shrinkage, and possibly the segregation of other constituents. The effects of shrinkage are fairly well understood by foundrymen, and they are generally able, by various means, to manipulate this in such a manner as not to affect the commercial soundness of castings. The various methods adopted in practice for the elimination of unsoundness in castings involve the use of feeder heads, control of the pouring time and the casting temperature. These various methods for the most part have the effect of removing all tendency to such visible unsoundness as blowholes and marked porosity, although they do not necessarily remove all traces and character of unsoundness.

It is well known to all engineers that in machining grey iron castings, even though visible unsoundness is absent, the further the machining approaches the centre of the thickness the tendency to porosity increases, in addition to the falling off in strength properties and the increase in coarseness of the crystal grains. In other words, whilst the general tendency to unsoundness towards the centre of a mass of cast iron can be frequently observed, there is no *a priori* reason why it should always be visible. Obviously its visibility depends upon the extent of the tendency to unsoundness in the first place, and we may only expect visible unsoundness when the extent is great. There is a strong tendency to believe that the phenomenon of the segregation of dissolved gases plays an important part in the production of this condition of internal porosity.

Once we admit the influence of dissolved gases it leads us to many interesting speculations which must, of course, be kept for experimental verification. There is no doubt that metallurgical thought is focussing its attention more and more on the influence of dissolved gases both on the question of soundness and the strength properties of cast iron as also in other industrial alloys. In the very recent issue of one of the French engineering journals, *L'Usine*, M. Guillet, in discussing what we term the inherent properties of pig-iron—and what they term in France, "L'Hérédité des Fontes"—makes the remark that "L'Analyse chimique, néglige notament les gaz occlus dont l'importance est parfois très notable."

It is certain that there are many defects in castings which appear to be only ascribable to dissolved gases, and the reason for the recurrence of these defects is often difficult to trace. There can be no doubt that they involve both the character of the pig-iron, the coke and melting practice, in addition to the thermal conditions appertaining during casting. Dissolved gases and their related phenomena present a very fruitful field of further inquiry.

Strength Properties.

Given the qualities or properties of soundness and machineability, high grade cast iron has commonly been defined on the basis of the strength properties. Reference to investigations fifteen to twenty years ago with the object of improving cast iron is sufficient to remind us that the outstanding desire was for high tensile strength. This search for high tensile strength, which, of course, has not diminished, was undoubtedly actuated by the intuitive knowledge that if this

* The author is the manager of the Centrifugal Castings Department of Messrs. Newton, Chambers & Company, Limited.

were obtained the other desirable properties would follow. As was to be expected, the attention of early systematic investigations were directed to the influence of the chemical composition as the principal factor in obtaining high tensile strength properties and the early, now classical experiments of Professor Turner are familiar to every student and ironfounder. It is of exceptional interest to recall the fact that these test bars were cast in 1885 and the maximum tensile strength obtained was 15.70 tons per sq. in.

It has been realised for a long time that the chemical composition alone is not the only factor in determining the strength properties, and that the structural character must inevitably exert an important influence. The results collected together in Table I consist of the chemical composition and tensile strength of some of the well-authenticated high strength cast irons which have been recorded. This collection affords ample evidence that the chemical composition alone is not the whole story in determining the strength properties. Considerable variations will be noticed in all the constituents, all accompanied by substantially high strength figures. Further convincing proof that some condition other than the chemical composition plays a large part in determining the strength properties can be had from the striking results obtained with modern refined pig-irons. Modern refined pig-irons are manufactured with consistent regularity which give tensile strengths of from 17 to 20 tons per sq. in. on test bars machined from the pig-iron. The comparison of these results with the early results obtained by Professor Turner is made in Table II.

Structural Composition.

From a knowledge of the structural composition, consisting as it does of a matrix of ferrite, pearlite, phosphide and sulphur constituents intersected by the free graphite, it would be expected that the size, arrangement and distribution of these would exert an important influence on the strength properties. In considering this, attention has been focussed on the graphite arrangement and distribution, and it has been generally considered to be axiomatic that the smaller the graphite size, the greater the strength properties for a given graphite content. Within limits, this axiom has proved extremely useful in the efforts to produce the best cast iron. It is now being steadily appreciated that even this is, however, insufficient in itself to explain all the differences in strength properties noticed. It is easy to produce samples of cast iron showing graphite size and distribution in the finest possible form showing strength properties considerably inferior to examples containing comparatively coarse graphite. There can be no doubt but that the influence of the graphite has been accentuated at the expense of both the size of the crystal grains and the constitution of the remainder of the structure. As a matter of fact, attention was first directed to the importance of the structure as a whole, more or less independently of the graphite size when Messrs. Cook and Hailstone discovered the importance of the network structure. This structure bears a general relation, and acts as an index of the structure of the material as a whole, and it has been shown that it can be connected up with at least one of the thermal conditions in the casting operation, viz., the casting temperature. The structure can be revealed by macro-etching, and this method of structural examination applied to cast iron is being attended by fruitful results.

Thermal Conditions.

The thermal conditions of casting involve the rate of cooling and the casting temperature—and it is generally appreciated that these conditions

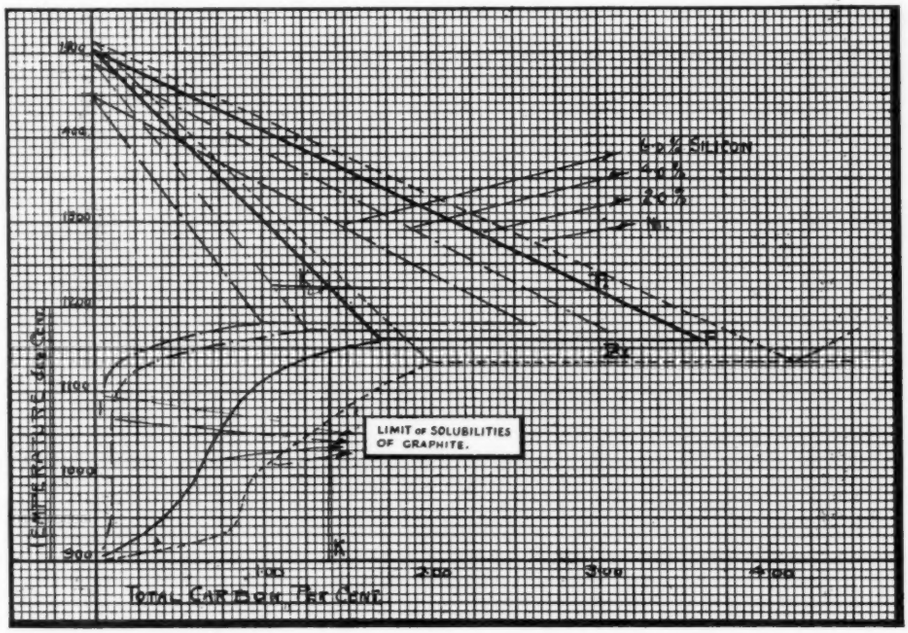

Fig. 1.—Limit of Solubility of Graphite in Iron-Carbon Alloys.

influence both the soundness and the strength properties of the castings. It is probable that their incidence in the production of sound castings is not so great in cast iron as in other industrial alloys—and for this reason it has not been necessary to exercise the same degree of control over these factors in the ironfoundry. Investigation has clearly shown, however, that these factors are of immense importance in the production of high-grade irons, and latterly much attention has been paid to the casting temperature and rate of cool ing as evidenced by the methods adopted of controlled pouring of castings and the use of hot moulds.

Low Total Carbon Content.

In practically all the high-grade cast irons there is general agreement that a low total-carbon content is a *sine qua non*. It is by no means commonly realised what an important difference in the mechanism of solidification is introduced by the adoption of such low total carbon contents. This is clearly demonstrated by the diagram, Fig. 1, which illustrates the approximate liquidus and solidus lines of the iron carbon alloys with increasing quantities of silicon. The lines indicating the 2 per cent. silicon alloy may be taken as typical of industrial cast irons—and with approximately 3.5 to 3.6 per cent. total carbon the alloy is the eutectic alloy having a single solidification point P with an excess of total carbon over 3.6 per cent., say, 3.75 per cent., the alloy becomes hypereutectic, and all our experience would lead us to expect that such an iron which is by no means uncommon would give large graphite plates on solidification in a normal manner. By reducing the total carbon content to 3.0 per cent., the alloy has a definte solidification range as indicated at P1 and P2, and the first material to be deposited is the solid solution having the composition indicated by the points K. In other words, the first material deposited on solidification is more or less of the nature of a steel containing about 1.5 per cent. carbon, together with silicon. Under these conditions it would be expected that the formation of the graphite would be definitely delayed until final solidification is reached. There is thus a distinct difference in the manner in which graphite is formed, occasioned solely by the reduction in total carbon content to 3.0 per cent., and this difference may well account partially for the improved properties of refined irons of low total carbon content.

At this stage the considerations in the production of high-duty cast iron must appear somewhat involved, and the question of soundness and strength properties only have been considered. In attempting to formulate a conception of the line of attack in the production of high-grade cast iron we are helped very considerably by what appears to be a broad relationship existing between the strength properties, the resistance to growth and wear. It must be clearly understood that this relationship is of a broad nature and cannot be interpreted any further than by saying that any feature of the composition, constitution or treatment which influences one or other of the three related properties—resistance to wear, growth or tensile strength—is likely to have a similar effect on the remaining properties. If we accept such a relationship the formulation of a conception readily simplifies itself, and it follows that if by modification of the chemical composition, structure, method of casting, or any other condition in such a manner as to influence any one of the above-mentioned properties, in the right direction, then all the properties are similarly influenced.

For example, we know from well-ascertained facts that if an iron of the lowest silicon content is used, compatible with commercial machinability, the resistance to growth and therefore the resistance to wear and tensile strength will be good. If, in addition, the iron is used with a low total carbon content, we know that the strength properties and hence the resistance to wear and growth will not be impaired if not increased. Further still, if we ensure the combined carbon contents being the highest possible compatible with commercial machinability and soundness, the whole of these three properties will be further improved. These considerations only hold providing the structural constitution is not altered and the thermal conditons remain constant.

It does not follow that such an iron will have the optimum of these properties, as this will obviously depend upon whether such an iron is accompanied by the optimum conditions of structural constitution and thermal conditions. We can go this far and say that if by any means these latter conditions can be improved in conjunction with the chemical conditions referred to in the previous paragraph, then we should expect from our relationship that we should obtain still better resistance to wear, growth and strength properties.

This indicates the general line of attack in the production of high duty cast iron from normal foundry materials. There is, of course, a tendency to consider the use of certain alloying elements, which in certain cases have been shown to be accompanied by improved properties. In a like manner the influence of thermal conditions, such as the casting temperature, or more rather production or melting temperature, is frequently considered as a result of certain German investigations. The centrifugal casting process is another method of special application, which influences these properties.

The ultimate value of these special methods is, of course, determined by purely commercial con-

siderations, but the relationships already deduced apply in these special cases.

Impact Resistance.

Before attempting to summarise, there still remains the question of impact resistance to be considered. Unfortunately the consideration of this property is somewhat complicated owing to the use of what might be termed compound tests for its determination. The indications of those tests are difficult to determine, either in relation to other more simple strength tests or the composition and structure.

It is not proposed to discuss this aspect of the subject further, and it will suffice to call attention to the main broad experience in this connection, which is that the impact resistance becomes greater with the lower phosphorus content, other conditions remaining the same. Where high resistance to impact is desired the phosphorus content should be reduced, and this is perfectly possible without affecting the broad considerations already deduced.

Modern High-Duty Cast Iron.

We might with advantage attempt to summarise the above considerations in the form of a rule to be followed in designing cast iron for high-duty conditions.

Cast iron for high-duty conditions should contain the lowest silicon content and total carbon contents, and the highest combined carbon contents compatible with commercial machinability and soundness of the castings. If high impact-resistance is desired it is desirable to reduce the phosphorus content. The graphite size and the grain size independently of the graphite size should be obtained in the smallest possible form.

To complete this rule, reference must, of course, be made to the use of certain alloy additions, which have been shown to have a beneficial effect. Their use will be principally determined by commercial considerations.

United Steel Company of Germany.

That German heavy industry continues to expand at home and abroad is indicated by the annual report of the United Steel Company (Vereinigte Stahlwerke A.G.), the largest producer of coal, iron and steel in Europe, which supplies the greater part of Germany's output.

Despite an increase of 4 per cent. in wages and a welfare burden which is three times that of before the war, United Steelworks through rationalisation continues to lower production costs.

In the course of the fiscal year ended September 30, 1927, the company spent about 100,000,000 marks on new buildings, of which two-fifths went into anthracite mines and cokeries. The largest of the new cokeries, the Bruchstrasse, has been completed, and is the largest battery of coke ovens in Europe. Six other cokeries are in construction, with an annual capacity of 3,500,000 tons. A part of the expenditure went on improving communications between the numerous companies of the corporation.

At the same time that the United Steelworks has been modernising its works it has been closing down antiquated and less productive ones. In the course of the year some 13 mines, 21 cokeries, 5 briquette works, 10 blast furnaces and some 20 small mills were closed down. Output has been concentrated in the most productive works.

The United Steelworks is participating in a wide variety of companies, among them one for piping gas some 400 miles about the Ruhr, and another for utilising coal by-products for synthetic fertilisers. Its output of pig-iron and of steel ingots shows a steady increase. The former was 981,758 metric tons, and increased in the third quarter of 1927 to 1,663,398 tons. Steel ingot output in the same period increased from 1,048,470 metric tons to 1,781,754 metric tons. The monthly average production of pig-iron increased last year, compared with the previous year, from 378,941 metric tons to 529,221 metric tons, and its steel production from 423,144 to 569,804 metric tons.

Tests for Cast Iron and Test Bar Problem.

Sheffield Metallurgists Discuss Testing Problems.

Following the lecture given by Mr. J. G. Pearce, B.Sc., the Director of the British Cast Iron Research Association, on "Tests for Cast Iron and Test Bar Problems," to the Sheffield Branch of the Institute of British Foundrymen, and printed in our last issue, an interesting discussion took place.

The Chairman (Mr. Ambrose Firth) said they had listened with very great interest to the Paper, and there was no doubt that the specification which the Association had been able to get accepted would be of very great value to ironfounders generally.

Mr. Goodwin (President of the Institute) said that Mr. Pearce was to be congratulated on the lucid manner in which he had dealt with this far-reaching work that had been so successfully launched out by the Test Bar Committee, on which both the Institute and the British Cast Iron Research Association were strongly represented. Being connected with both the Institute and the Association, he, Mr. Goodwin, had personal knowledge of the enormous amount of work that had to be done before this specification could be issued. They had wisely worked in conjunction with various important engineers in this country in order that their acceptance of this specification, when finally presented, would be a foregone conclusion. Both the metallurgist and the engineer had been seeking knowledge for a considerable number of years on the subject of test-bars, and it was gratifying to find that the results of the work done had brought about a general agreement.

Not the Last Word.

He believed that no manufacturer should have any difficulty in meeting the specification in question if he took advantage of the facilities offered for obtaining practical and technical knowledge, and the exchange of ideas at the lectures of the Institution. There were, however, many things Mr. Pearce had said which led one to believe that this was not the final specification. There were many difficulties in the future to face, when the specification for still higher grades of cast iron was drawn up, and before this could be done, one realised that a large amount of investigational work would be necessary. He asked if it had been attempted in the research which had been carried out in the laboratories to machine two test-bars, one from the top edge and one from the bottom edge, of an ordinary 2 × 1 tensile cast on edge, and if so, what were the results? As from his experience, he found that there was a considerable difference in the two tests.

The French had attempted to give the engineer a test-bar cut from the casting, but unfortunately, in his opinion, the method of doing so was less likely to represent the casting, than would a separately cast test-bar of the same metal, especially as it is now possible to choose a test-bar the area of which will cool at the cooling rate of the casting to be made.

Also, the method of machining the French test-bar, caused it to set up naturally small cracks which had an adverse effect on the ultimate breaking load of the bar, and unless those responsible were prepared to enlarge the diameter and grind the specimen in the same way as is done with British bars after machining, good results would not be obtained. He looked forward to the International Conference report from Mr. Pearce on the whole of the test-bar question.

Commander Jackson said that they were fortunate in having both the lecturer and Mr. Goodwin, the President of the Association, who was also a member of the Test-Bar Committee, present, to tell more about this important subject. He asked if any of the test pieces had been cast round in section, and then prepared and tested.

He also asked if the Admiralty, War Office, Lloyds and other bodies would substitute their existing specifications to the proposed specification as described? He also said that a tolerance of one-tenth of an inch seemed to be rather excessive.

Mr. E. J. Brown said that he understood Mr. Pearce to say that the different results obtained on testing a round bar as cast, compared with a round bar that had been machined from the square, was a testing effect and not a casting effect. This was not quite clear. On casting a square-sectioned bar, cooling, of course, would proceed from each face and would result in diagonal lines of weakness. These lines would surely affect the result of the test; it therefore seemed reasonable to suggest that the difference obtained was due to casting and not to testing.

With regard to the question of whether or not the test bars should be part of the casting, he was inclined to the view, all things considered, that, provided discrimination was used, it was better for the bar to be on the casting.

Mr. Pearce had recommended that the result of transverse tests should be expressed as modulus of rupture. If the sectional shape of a bar can influence the breaking load seriously, when the figure is expressed as weight per area section, such a fact would tend to discount the calculated values obtained.

Mr. Pearce, in reply to the points raised by Mr. Goodwin, said that if transverse test bars were machined from the top and bottom edges of a 2-in. by 1-in. transverse bar, the results would be very different. It was well known that the result from the 2-in. by 1-in. bar varied according to the way in which the bar was poured and tested. Tests of the kind mentioned had been made, to his knowledge, from broken 2-in. by 1-in. bars, which were machined to 1-in. square and tested at 12-in. centres. There was usually on the 1-in. bars a relative increase in stiffness—that is, in breaking load—and a decrease in deflection, and there was a difference between the bar from the top and the bar from the bottom. So far as he knew no tests had been made after the manner of the Frémont test on over-size bars ground or machined to size.

In reply to Commander Jackson, he said that all the important authorities mentioned have been represented on the B.E.S.A. Committee and would doubtless use the specification in place of individual specifications hitherto used. He agreed that the tolerance was on the high side, but it was better not to make a specification too stringent to start with, but to improve it later as founders got accustomed to using it.

In reply to Mr. Brown, he said that part of the difference between the round bar and square bar was undoubtedly a casting effect. The test referred to in the paper showed that what had hitherto been supposed to be wholly a casting effect was, in part, a testing effect, because the round bar gave better results than the square bar, irrespective of the shape of the bar from which either had been machined. No doubt, as a result of a good deal of experience, it was possible to arrange a cast-on bar fairly to represent a casting, but this cannot be said of all cases.

In calculating rupture modulus the shape of the bar was taken into account in the formula by means of the factor Z, or section modulus.

At the close of the meeting Mr. Pearce was accorded a very hearty vote of thanks for his highly interesting paper.

Catalogue Received.

A Special Alloy.—We have received from the Deloro Smelting & Refining Company, Limited, of 14, Waterloo Place, London, S.W.1, a series of very helpful catalogues dealing with "Stellite," a non-ferrous alloy of cobalt base which competes with high-speed steel, but obviously has its own special technique. We feel sure that this is an alloy about which foundrymen should make themselves familiar. It appears to us that it is possible that a combination of cast iron, or maybe cast steel, tipped with "Stellite" could put up a fair competition with all special steel material. Many founders are experienced welders (no reflection is implied here), and it is by this process that "Stellite" is joined to cast iron, "semi-steel" (apparently this word refuses to die) and malleable iron. It is profoundly difficult to estimate the importance of "Stellite" to the foundry industry, as it may be regarded as ancillary to the making of castings or as part and parcel of its requirements for tool steel.

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[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Electrode Consumption and Mechanical Charging.

To the Editor of The Foundry Trade Journal.

Sir,—In your issue of February 2 there appeared a Paper by Mr. H. S. Primrose, A.M.I.M.E., read before the Lancashire Branch of the Institute of British Foundrymen, in which a number of statements are made relating to electric furnaces of the arc type.

This Paper has been carefully studied by the writer during a recent trip on the Continent, which at the same time permitted of opportunities for verifying certain data which seem to conflict somewhat with some of the information given by Mr. Primrose.

It has been observed that, under the section devoted to electrodes, the statement appears that on electric arc furnaces of 2-ton capacity or less graphite electrodes are usually employed, thereby inferring that, on electric arc furnaces of larger capacity, it is not the general practice to use this type of electrode.

It is further contended, presumably on behalf of carbon electrodes, that, from the metallurgical point of view, a large electrode is advantageous, as the arc is less localised and a larger area is directly heated. This contention is quite consistent with the use of graphite electrodes on all capacities of furnaces, within the limits of size governing the manufacture of this type of electrode. For example, on electric arc furnaces of 15-ton capacity and over graphite electrodes of 350 and 400 mm. diameter are generally employed, with the maximum of advantages from the large heating area. The advocates of carbon electrodes have always maintained that, by reason of the larger sizes which it is necessary to use, a larger arcing area is available, but in practice this is seldom realised, as owing to the lower temperature of oxidation of carbon electrodes the tapering is usually so excessive as to present an active arcing area in most cases considerably less than that presented by, for example, a 350 or 400 mm. graphite electrode, or *pro rata*, any intermediate size. The modern tendency towards the employment of transformers of much larger capacity than hitherto introduces a much higher melting voltage, with such higher amperage as necessitates operating at higher current densities, thereby rendering ordinary carbon electrodes unsuitable. Indeed, it is due to the development of the larger sizes of graphite electrodes, particularly 14, 16, and 18 in. diameter, that there has been in recent years such a conspicuous expansion of large capacity electric furnaces of 15 tons and over, exploiting to the full all the advantages of large power input. It may be stated, without fear of contradiction, that the majority of electric furnaces in operation throughout Europe, of all capacities up to 15 tons and over, are successfully and economically utilising graphite electrodes.

For instance, modern furnaces of 15- to 20-ton capacity now employ transformers of 3,500 to 4,000 k.v.a. capacity, with a secondary melting voltage of 150 to 180, and an amperage per phase of 15,000 up to 18,000 amperes. To meet such electrical conditions would require a size of carbon electrode of almost impracticable dimensions, so that in almost all such installations throughout Europe and in America graphite electrodes of 350 and 400 mm. diameter are of necessity employed. The same tendency towards the use of higher melting voltage and rapid power input is in evidence on furnaces of medium capacity, so that it may be confidently claimed that generally, where such modern requirements appertain, graphite electrodes seem indispensable.

It may be helpful to cite a few typical cases of modern furnaces. (1) One 6-ton capacity; transformer capacity—1,750 k.v.a.; secondary voltage—180 to 230; amperage per phase—5,000 to 6,000. (2) Another of 9-ton capacity; transformer capacity—2,000 k.v.a.; secondary voltage—110 to 150; amperage per phase—8,000 to 9,000. (3) Four 15- to 20-ton furnaces; transformer capacity—3,500 to 4,000 k.v.a.; secondary voltage—130 to 180; amperage per phase—16,000 to 18,000; using 350 mm. graphite electrodes. (4) One 15-ton furnace; transformer capacity—5,000 k.v.a.; secondary voltage—104 to 183; amperage per phase—14,000; using 350 mm. graphite electrodes. (5) One 15-ton furnace; transformer capacity—5,500 k.v.a.; secondary voltage—100 to 180; amperage per phase—15,000; using 400 mm. graphite electrodes. (6) One of the latest Héroult furnaces in operation in America, 25-ton capacity; transformer capacity—7,500 k.v.a.; secondary voltage—115 to 275; amperage per phase—17,350 to 26,600; using 400 mm. graphite electrodes.

As a result of intimate contact with the leading European electric furnace designers, it may be stated that, in the majority of cases new furnaces of all capacities are designed for graphite electrodes. These furnaces, moreover, of capacities up to 10 tons in England, and up to larger capacities in such countries as France, Germany, Italy, etc., are almost exclusively employing graphite electrodes. Indeed, generally speaking, throughout Europe, only the very old types of furnaces are using carbon electrodes.

Under the heading of "Cost Items," Mr. Primrose gives the consumption of amorphous electrodes as usually from 30 to 40 lbs. (13.5 to 18 kgs.), and for graphite electrodes, from 12 to 18 lbs. (5.5 to 7.25 kgs.). No mention, however, is made as to the class of steel produced, or the nature of the scrap employed, the two governing factors in comparing electrode consumptions. In the production of alloy steels, 40 lbs. per net ton of ingots produced is more generally the average amorphous carbon consumption, whereas for the same class of steels, with graphite electrodes, the average electrode consumption is about 13 lbs.

On the Continent, where for various reasons there has been, over the past few years, a much greater development of the electric arc furnace along modern lines than in England, many cases could be cited of furnaces of capacities ranging from 3 up to 10 tons, employing high voltages from 150 to 180, and in some cases even higher, where in the production of high-class alloy steels the net graphite electrode consumption varies from 10 to 14 lbs., according to the class of scrap employed.

Clearly there would not be such a widespread use of graphite electrodes, and their almost exclusive adoption in all modern electric arc furnaces, if the electrode consumption ratio compared with carbons, was only 2.5:1. In point of fact, the average ratio throughout Europe is more nearly 3.5 to 4:1.

Mechanical Charging.

In your issue of February 9 there appeared the discussion on Mr. Primrose's paper, from which it is somewhat surprising to observe a statement to the effect that mechanical charging by charging machines, similar to those employed on open-hearth furnaces, is not possible in the electric furnace. It is not disputed that hand charging is still largely utilised on electric furnaces, but mechanical and semi-mechanical charging has been practised at a number of electric furnace plants throughout Europe for some years past.

Of recent years there has been a considerable development in America towards the mechanical charging of electric furnaces, especially of capacities from 10 tons upwards, and such practice is being closely studied by many European electric steel-works. It may not be generally known that charging machines of a similar type to those used in the charging of open-hearth furnaces are utilised in a number of German plants, and have been employed, to the writer's knowledge, for a number of years in several Italian plants.

While machine charging is necessarily restricted to furnaces of large capacity, from 15 up to 30 tons, yet it is of some interest to mention that a certain amount of study is now being devoted to the application of mechanically-operated shutes for the charging of medium-capacity furnaces. This method is limited in its application to plants having available ample supplies of medium-sized scrap. A number of shutes are used and hand-loaded, while the furnace is in operation, so that, after pouring, at least 50 per cent. of the scrap can be shute charged in a fraction of the time ordinarily required for hand charging.

The most efficient employment of machine charging is that of the Timken Roller Bearing Company, of Canton, Ohio, U.S.A. The charging machines they use were, we understand, manufactured by the Alliance Machine Company, Alliance, Ohio, U.S.A. The Timken Company employ two 25-ton Heroult furnaces; Transformer rating—7,500 k.v.a.; secondary voltage, equipped with triple voltage control—115 to 275; charging, 33-35 tons of cold scrap and producing high-grade alloy steels—nickel, chrome, molybdenum, vanadium, and their combinations, with 400 mm. graphite electrodes.

The following data may prove of interest:—

Furnace No.	Average charge per heat.	Average time from tap to start charging.	Average time to charge.	Average time, Power off to power on.	Average time per heat.	Average time per ton.
	Tons.*	Minutes.	Minutes.	Minutes.	Hrs. Mins.	Minutes.
2	33—35	17	16	33	5 10	9.3
3	33—35	19	17	36	3 52	7.0

* American short ton of 2,000 lbs.

The capacity of the loading boxes is 2,500 lbs. of light scrap, or 5,000 lbs. of heavy scrap, and the scrap charged consists generally of light forgings, and plates and briquetted turnings, the briquettes being 8 in. in diameter and about 5 in. long.

In most European large-capacity electric furnaces using charging machines the charging is not nearly so fast as that on the American furnaces mentioned. The reason for this is that most of the European furnaces were not in the first instance designed for mechanical charging, so that it is only possible to machine-charge a certain proportion of the scrap. On a large installation of 15-20-ton Heroult furnaces in Italy, where machine charging is employed, of an average charge per heat of 22 tons of scrap, approximately 12 tons is machine charged, the time occupied being 45 to 50 minutes.

The loading boxes are of much smaller capacity, i.e., approximately 1,210 lbs., and it is the practice of this plant to switch on the current immediately on the completion of the machine charging, and to complete the charge by hand, while the furnace is in operation. The plant in question is using graphite electrodes, and despite the more severe oxidising conditions prevailing the average electrode consumption over a period of approximately 2½ hours, with four workmen hand charging, and producing plain carbon steels, is 10 to 10.5 lbs. per net ton of ingots produced.

The practice of machine-charging naturally varies in the different European plants, but as far as the writer is aware there are no plants exclusively machine charging; that is to say, a certain amount of hand charging has to be resorted to.

It is hoped that these remarks may prove useful to some of your readers, as supplementary to the discussion on this excellent paper on "Electric Melting."—Yours, etc., E. G. Acheson, Limited.

A. Kerr, Sales Engineer.

40, Wood Street, Westminster.
London, S.W.1.

Composition of Cast Iron.

(*Continued from p.* 225.)

action is caused by the small proportion of silicide.

The diagram of the two pig-irons, East Coast hematite and Cleveland, are interesting in showing the huge difference in the proportions of the phosphide eutectic, with the consequent inverse influence on the proportions of carbon.

In the diagrams the volume of the silico-ferrite is represented by the unshaded portion, and that of the sulphides by the dark portion. Actually, each diagram is an "ensemble" representation of each of the structural constituents, as would be revealed by a complete microscopic examination.

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Trade Talk.

Parsons Marine Steam Turbine Company, Limited, of Wallsend-on-Tyne, have received the order for the engines for the new British light cruiser to be built at Devonport Dockyard.

Mr. H. R. Davis, consulting engineer and marine surveyor, of 321, Tower Building, Liverpool, has been appointed representative for Liverpool and district for the shipbuilding, engineering, and shiprepairing firm of J. Samuel White & Company, Limited.

The Shell-Mex Oil Company have placed a contract with Perkins & Sons, Limited, of Bristol, for the erection of a large storage tank at their Jarrow depot. The steel work for the tank will be supplied by the Whessoe Foundry & Engineering Company, Limited, Darlington.

In regard to the reference made to the Standing Committee under the Merchandise Marks Act, 1926, in respect of imported enamel zinc sheets, the Board of Trade give notice that reports have been made by the Committee, and may be purchased from H.M. Stationery Office.

The Butterley Company, Limited, 52, Queen Victoria Street, London, E.C.4, have again secured the contracts for the supply of the whole of the cast-iron special pipes for the Metropolitan Water Board for the coming twelve months from April 1 next, having been the contractors for the past twelve months also.

The Wallsend Slipway and Engineering Company, Limited, have secured the contract for the engines for the new flotilla leader ordered from Swan, Hunter and Wigham Richardson, Limited, while Hawthorn, Leslie & Company, Limited, will supply the machinery for the two destroyers they are to build at their Hepburn shipyard.

The directors of Vickers, Limited, are making arrangements to transfer their aviation works at Weybridge to a new subsidiary company, which is to be called Vickers (Aviation), Limited, and it is also proposed to transfer the Crayford works to a new subsidiary company, to be called Vickers (Crayford), Limited. These transfers can be carried out without payment of stamp duties, and the directors consider that it will be more convenient and economical in working if these businesses are constituted as separate companies.

The Riley Stoker Company, Limited, Palace Chambers, Bridge Street, London, S.W.1, inform us that after inspection of the large Harrington stokers using pre-heated air at the Barking power station of the County of London Electric Supply Company, the Oxford Electric Company, Limited (owned by Greater London and Counties Trust, Limited), have adopted, for each of their large new boilers, a single Harrington travelling-grate stoker, having 360 sq. ft. active grate surface, and using pre-heated air. Pre-heated air is also used on three Harrington stokers working at Kirkcaldy.

The Oerlikon Company are now building for the Handeck Power Station of the Oberhaeli Power Supply Company, Switzerland, three-phase vertical generators each for a continuous rating of 28,000/32,000 ZVA at 500 RPM, 11,000 volts. The units in question are the largest which it is contemplated to install within the near future in Switzerland. When the Handeck Power Station is fully developed, the plant there will comprise four such sets. Particulars of the generators are given in Bulletin No. 81 just issued by Oerlikon, Limited, of 28-31, Essex Street, W.C.2.

The annual meeting of the West of Scotland Iron and Steel Institute was held on March 16 in the Royal Technical College, Glasgow, Mr. John Craig, the president, in the chair. The annual report, read by the secretary, Mr. Douglas A. MacCallum, stated that the membership numbered 589—a net increase on the year of 7. Office-bearers for the ensuing year were elected as follow:—President, Mr. R. Crichton; vice-presidents (two vacancies), Mr. George Ness and Mr. T. B. MacKenzie; treasurer, Mr. Douglas A. MacCallum; and members of council (four vacancies), Mr. William Macfarlane, Mr. W. H. Cathcart, Mr. J. Bird, and Mr. J. Percival Smith. Afterwards two papers were read—one entitled "Notes on Electrical Dust Precipitation," by Mr. E. H. Lewis, and one entitled "Notes Concerning Fractured Boiler Plates," by Mr. George Ness and Mr. Douglas A. MacCallum.

The Board of Trade state that, in pursuance of applications received for the making of Orders-in-Council to require certain imported goods to bear an indication of origin, they have made a reference to the Standing Committee appointed by them under the Merchandise Marks Act, 1926, in respect of the following classes and descriptions of imported goods:—Ball and roller bearings of all descriptions, finished or unfinished and parts thereof, finished or unfinished, other than the balls, rollers or cages; vacuum cleaners, electrically worked; copper tubes; (*a*) pumps of all descriptions (other than semi-rotary wing pumps); (*b*) parts of pumps of all descriptions. Representatives of any interests affected who desire to be heard in opposition at the public inquiry are requested to communicate with the secretary, Mr. E. W. Reardon, at the New Public Offices, Great George Street, London, S.W.1.

Negotiations for the amalgamation of the machine tool business of Sir W. G. Armstrong, Whitworth & Company, Limited, Openshaw, and Craven Bros. (Manchester), Limited, Reddish, and Joshua Buckton & Company, Leeds, have been completed. Brett & Company, Manchester, acting on behalf of Craven Bros., said the company was acquiring the goodwill of the other two businesses, whose establishments would close and the work transferred to Vauxhall Works, Reddish. Under the agreement made with Vickers, Limited, for the fusion of armament and shipbuilding interests, the machine tool business of Sir W. G. Armstrong, Whitworth & Company, at Openshaw, was excluded from the deal, it being announced that this department would be transferred to the Scotswood Works. Craven Bros. (Manchester) was registered in 1886, and has an authorised share capital of £300,000. There is also £70,000 of 6½ per cent. mortgage debentures. For 1918 a dividend of 12½ per cent. was paid, plus a capitalised bonus of 20 per cent., and dividends at varying rates were paid up to 1923, but no dividend has been paid on the ordinary since, while the preference dividend is in arrears as from August, 1926. Joshua Buckton & Company were incorporated in August, 1883. The authorised capital is £150,000, in £1 shares, all issued and fully paid. At the end of June last there was a loan of £72,414 secured by debentures. No dividends have been paid for the past six years.

Personal.

Mr. B. D. F. Docker has been elected a director of the Metropolitan-Vickers Electrical Company, Limited, and also deputy-chairman.

Sir Alexander M. Kennedy, chairman of the Northumberland Shipbuilding Company (1927), Limited, has undergone a serious operation, but is progressing satisfactorily.

Sir Daniel Neylan has joined the board of Sir William Arrol & Company, Limited. Sir Daniel has had a distinguished career in connection with Government Departmental finance.

Mr. G. Williamson has been appointed by Palmers Shipbuilding and Iron Company, Limited, to a managerial position at their Jarrow Shipyard, where Colonel Macdonald is manager.

Sir George B. Hunter announced his retirement from the chairmanship of Swan, Hunter, & Wigham Richardson, Limited, at the annual meeting at Newcastle. Mr. T. E. Thirlaway, vice-chairman, succeeds him as chairman, but Sir George will remain a director of the firm.

Mr. A. Logan, of Messrs. R. & W. Hawthorn, Leslie & Company, Limited, St. Peter's Works, Newcastle-on-Tyne, whilst still retaining his present position with that firm, is now at liberty to undertake independent consulting work, including analysis, metallography, and investigation of works' and foundry problems of all kinds.

Mr. S. Robinson, who for the past 35 years has held the position of machine shops manager at the River Don Works (Brightside) of Vickers, Limited, is retiring at the end of this month. Mr. Robinson joined the staff of the company in 1890, on the retirement of Mr. James Laycock, and in 1892 he was appointed manager in succession. For upwards of 30 years he has had as chief assistants his two brothers, Mr. John W. Robinson and Mr. Edwin Robinson, who are also retiring.

Will.

Gott, R., ironfounder, Heaton House, York Place, Knaresborough £27,485

New Companies.

Flexo Steels, Limited.—Capital 5,000 in 5,000 ordinary of 1s. and 4,750 8 per cent. cumulative preference of £1.

Hebburn Steel Castings Company, Limited.—Capital £5,000 in £1 shares, to acquire business of cast steel founders carried on by S. Oake, E. Foxall and E. H. Holt as the Crucible Steel Castings Company at Glenside Works, Hebburn. O. R. Gibbon first managing director. Secretary: E. Foxall.

Malleable Steel Foundry Company, Limited, Pendleton.—Capital £6,000 in £1 shares.

Contracts Open.

Aldeburgh.—Supplying, laying and jointing 6-in., 4-in., 3-in. and 2½-in. C.I. water mains, for the Corporation. The Borough Surveyor.

Glasgow, April 7.—Materials for the Corporation:—Bolts and nuts; brass cocks, etc.; cast-iron pipes and special castings; cast-iron castings, etc.; drip pans, grill pans and grids; engineers' furnishings; gas cookers; gas and steam tubes and fittings; hammer handles, etc.; hotplates for kitchen ranges; hydraulic leather packings; ironmongery; lime and cement. The General Manager, Gas Department, 30, John Street, Glasgow.

Swansea, April 2.—Iron and steel, etc., for the Pacific Patent Fuel Company (1920), Limited. The Offices, 4, Mount Street, Swansea.

Warrington, April 10.—500 galvanised steel ashbins and covers and 500 galvanised steel sanitary pails, for the Town Council. Also alternative tenders for 1,000 of each. The Cleansing Superintendent, Central Sanitary Depôt, Howley, Warrington.

Hampton-on-Thames, April 17.—Supply and erection of two sets of vertical centrifugal well pumps and electric motors, etc., for the M.W.B. The Offices of the Board, Chief Engineer's Department (Room 173). (Fee £1 1s., returnable.)

Sandbach, April 2.—Supply and fixing at Sandbach 10-ton self-contained lorry weighbridge, etc., for the Urban District Council. Mr. A. E. Stringer, 3, Crewe Road, Sandbach.

Southampton, April 12.—Supply and erection of electric travelling crane, for the Harbour Board. Mr. E. Cooper Poole, engineer to the Board.

Obituary.

Mr. H. Terry, of Hilton Terrace, Earlsheaton, Dewsbury, a partner in T. Ottewell & Company, scrap and machinery merchants, Dewsbury, died last week at the age of 62.

Mr. George Henley, director of William Dove & Sons, Limited, ironfounders, of the Pavement, York, died recently at the age of 76. He had been employed with the firm for 50 years, and 6 years ago was elected a director.

The death of Mr. J. A. de Matern, managing director of the Stora Kopparbergs Bergslags Aktiebolag Agency, Limited, 6, Laurence Pountney Hill, Cannon Street, London, E.C.4, occurred on March 21 at his residence, Devonshire Lodge, 15, Marylebone Road, N.W.1.

Colonel R. Peacock has died at his residence, Sunninghill, Ascot, at the age of 90. The deceased was the eldest son of Richard Peacock, founder of the firm of Beyer, Peacock & Company, Limited, Gorton, Manchester. His father started the Gorton Foundry in 1854, and it was there that the deceased began his engineering training.

Reports and Dividends.

Butterley Company, Limited.—Third interim dividend, 2d. per share, tax free.

Fawcett, Preston & Company, Limited.—Interim dividend, 5 per cent. on ordinary shares.

Vickers, Limited.—Dividend for year, 8 per cent. per annum, less tax, on ordinary shares.

Bengal Iron Company, Limited.—Final dividend on preference shares for year ending March 31.

Henry Bessemer & Company, Limited.—Net profit, £11,312, compared with net loss £27,667 in 1926.

Gibbons (Dudley), Limited.—Net profit, £14,628; brought in, £10,101; dividend, 3 per cent., free of tax, on ordinary capital, making 10 per cent.; balance forward.

Clarke, Chapman & Company, Limited.—Net profits, £39,750; brought forward, £3,246; final dividend, 5 per cent. on ordinary shares, making 7 per cent. for year; carry forward, £7,022.

Hadfields, Limited.—Profit, £187,223; brought forward, £44,190; total, £231,413; debenture interest, £57,155; dividend on preference shares, £13,500; ordinary dividend, 5 per cent., less tax; carried forward, £86,366.

G. D. Peters & Company, Limited.—Net profit, £4,638; income-tax reserve written back, £5,436; balance brought forward, £12,830; Indian income-tax, £180; transferred to special reserve re subsidiary companies, £15,000; carried forward, £7,724.

It is stated that the control of the Hoffmann Company has recently been acquired by Brown, Bayley's Steelworks, Limited.

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Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—It is, of course, as yet too early to form any exact estimate of the result of the recent advance in Cleveland iron prices, but so far it may be said to have effected a slight check on buying activity, and consequently market business has been restricted to some extent. In the existing conditions consumers hesitate to face even this slight rise on their costs, and are holding off the market until there is more definite evidence that no relapse is likely. Home sales have consequently been rather limited, and the export section shows no resilience such as would offset the quieter tone of the home trade. However, the ironmasters profess the utmost confidence. They are certainly well sold for the next couple of months, and are firmly resolved to adhere to a policy of maintaining prices by restricting output. The current price of No. 1 Cleveland foundry iron is now quoted 68s. 6d. per ton; No. 3 Cleveland G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge iron, 64s. 6d. per ton.

Production in the East Coast hematite industry is now reduced to only ten blast furnaces, and although South Wales continues to take fair quantities, the tonnage passing into consumption is not sufficient to make much impression on the big stocks on makers' hands. Meanwhile makers' quotations are unchanged at 70s. per ton for mixed numbers and 70s. 6d. for No. 1 quality. On the North-West Coast Bessemer mixed numbers remain at 70s. per ton at works, with low-phosphorus iron between 2s. 6d. and 5s. per ton higher.

LANCASHIRE.—The opening of the second quarter has introduced a rather steadier tendency in local markets for foundry pig, and a number of inquiries in circulation are expected to materialise in actual business in the near future. Prices on the whole are fairly maintained, with Staffordshire offering at round 71s. 6d. per ton, delivered Manchester or equal. Derbyshire at from 72s. to 72s. 6d., according to quantity, Cleveland at 79s. 2d., Scottish brands at from 86s. to 87s. 6d., and West Coast hematite iron at from 84s. to 84s. 6d.

THE MIDLANDS.—Consumers of foundry pig in the Black Country area for some time past have been buying in restricted quantities, and at the moment there is little evidence of an early improvement in this direction. In the meantime, stocks at works are very low. Northampton iron No. 3 is quoted at 58s. 6d. to 59s. at furnaces, No. 3 Derbyshire is 64s., and North Staffordshire at 63s. 6d. to 64s. 6d. at furnaces, with Scotch No. 3 between 90s. and 91s. delivered.

SCOTLAND.—The volume of business passing in the market for Scotch pig-iron of late continues disappointing, but prices are still firm on the basis of 70s. for No. 3 foundry at the furnaces; in fact, some makers, on the plea of having to pay more for their ore, are trying to get 1s. per ton more. All sections of the foundry trade, however, are very quiet, and in many cases only three or four days per week are being put in.

Finished Iron.

Makers of this class of material in the Black Country area report that orders for crown and the cheaper qualities of iron are still very scarce, and there now obtains very keen competition for what limited business is being offered. The price for crown iron continues to vary to a considerable degree; anything from £9 up to £10 5s. is quoted, with second grades down to £8 12s. 6d. per ton. Nut and bolt iron from local works is quoted at £8 15s. to £8 17s. 6d. per ton, but little support is possible at this rate as the bulk of the business is going to the Continent on account of the disparity in price. Staffs marked bars are quoted at £12 10s. basis at makers' works, and makers of this class of iron are moderately busy.

Steel.

As recently reported, there has been a weaker tendency noticeable in the Continental steel market, and this has influenced buyers in the direction of holding back purchases. The chief feature of the market is the increasing number of Continental works which appear to be in a position to give delivery within a reasonable time, in spite of the fact that a few weeks ago they were only quoting for delivery many weeks ahead. At Sheffield the prices now demanded for billets and rods from the Continent have resulted in more business coming to local steelmakers, and in consequence production of basic steel is being increased. Output of acid steel is likewise being expanded. Siemens acid billets are £10 per ton delivered, and prices of basic qualities are:—Soft, £6 5s.; semi-hard, £7; medium hard, £7 2s. 6d.; hard, £7 12s. 6d. Current quotations for coke tinplates may now be called 18s. to 18s. 1½d. basis for approved specifications, with option of lights and crosses, and 3d. basis extra for squares and odd sizes, net cash, f.o.b. South Wales ports.

Scrap.

The recent advance in Cleveland iron prices has to a certain extent somewhat stimulated demand for scrap material for foundry purposes, and at Middlesbrough last week an upward move in heavy cast-iron quality was not unexpected, merchants only selling small quantities at current rates, which are 62s. per ton for ordinary quality, and 66s. for machinery quality. In the Midlands the demand for cast-iron scrap has been well maintained, but prices are somewhat easier. Heavy cast-iron machinery scrap, in cupola sizes, is offered at 67s. 6d. per ton delivered, and light cast-iron scrap is weak at 53s. per ton delivered. In Scotland machinery cast-iron scrap is firm at 70s. per ton for material suitable for foundries and in pieces not exceeding 1 cwt. Heavy ordinary cast-iron scrap to the same specification is 5s. per ton less. Old cast-iron railway chairs are still commanding 67s. 6d. to 68s. 6d. per ton. Light cast-iron scrap is 60s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Following a slight reactionary movement last week, values of warrant copper have again entered upon a steadier tendency, and at the close showed a small advance of 10s. per ton. There has been no change in the official quotations for electro, which stands at £66 10s. to £66 15s., while a fair quantity of wire bars were taken recently by cable makers at £66 13s. 9d. c.i.f. U.K., for second half of April arrival. Official closing prices:—

Cash.—Thursday, £61 7s. 6d. to £61 8s. 9d.; Friday, £61 5s. to £61 6s. 3d.; Monday, £61 7s. 6d. to £61 8s. 9d.; Tuesday, £61 11s. 3d. to £61 12s. 6d.; Wednesday, £61 12s. 6d. to £61 13s. 9d.

Three Months.—Thursday, £61 7s. 6d. to £61 8s. 9d.; Friday, £61 6s. 3d. to £61 7s. 6d.; Monday, £61 8s. 9d. to £61 10s.; Tuesday, £61 12s. 6d. to £61 13s. 9d.; Wednesday, £61 15s. to £61 16s. 3d.

Tin.—The sharp advance in cash quotations for standard tin to some £13 above the previous week's level may be taken as expressive of returning confidence on the part of buyers, and with more favourable American advices the market is evidently in a more cheerful mood than has recently been apparent. The prospects, too, are distinctly brighter. The statistical position at the end of the month is likely to show improvement owing to lighter shipments from the East, heavier deliveries to America, and decreasing stocks in the United Kingdom. Official close:—

Cash.—Thursday, £238 10s. to £238 12s. 6d.; Friday, £240 2s. 6d. to £240 5s.; Monday, £239 10s. to £239 15s.; Tuesday, £239 17s. 6d. to £240; Wednesday, £238 to £238 5s.

Three Months.—Thursday, £238 5s. to £238 10s.; Friday, £239 15s. to £240; Monday, £238 15s. to £239; Tuesday, £239 5s. to £239 10s.; Wednesday, £237 5s. to £237 10s.

Spelter.—In connection with the market position of ordinary spelter, Rudolf Wolff & Company write:—The situation presents little or no material change; consumption is fairly well maintained in this country, but reports from the Continent are none too reassuring, and production there remains on the full side, with very little indication of any curtailment in this direction in the near future; negotiations in this respect are still being continued, but so far no definite results have been reported. Closing prices:—

Ordinary. — Thursday, £25 3s. 9d.; Friday, £25 3s. 9d.; Monday, £25 3s. 9d.; Tuesday, £25 2s. 6d.; Wednesday, £25.

Lead.—Only intermittent interest has been evidenced by consumers of soft foreign pig, whether in this country or on the Continent. The American statistics, showing an increase in the stocks on March 1 of 10,000 short tons, had very little effect on prices, it being noteworthy that the market is showing greater resistance to unfavourable news. Closing prices:—

Soft Foreign (Prompt).—Thursday, £20 8s. 9d.; Friday, £20 5s.; Monday, £20 2s. 6d.; Tuesday, £20; Wednesday, £20.

Meetings of the Committee appointed by the Board of Trade to consider whether a duty should be imposed on enamelled hollow-ware will be held on Friday and Saturday, March 30 and 31, at 10.30 a.m. on each day, in Room 76, First Floor, at the Board of Trade Offices, Great George Street, Westminster, S.W.1.

Direct Steel Process in Sweden.—A new company has been formed at Stockholm, under the name of Flodin-Järn A.B. (Flodin Iron Company), to work the Flodin and Gustafsson patents for producing wrought iron and steel direct from the ore in electric furnaces. Experimental smeltings at the Uddeholm Company's plant have given excellent results. The process was described at the autumn meeting of the Iron and Steel Institute at Birmingham in 1925.

Do you *know* all the Potentialities of the *modern* Reverberatory Furnace? You *can* by writing to:

BRITISH REVERBERATORY FURNACES COMPANY, LIMITED
At 82, Victoria St., London, S.W.1.

They are SPECIALISTS with a wealth of experience to call upon.

LEGGE'S IRON CEMENT

Reliable for Ironfounders and Engineers.

Permanently rectifies defects in Castings and Leaking connections in Steam, Gas, Water, &c.

Agents wanted where not already represented.

F. THOMPSON LEGGE & CO.
43, DUKE STREET LIVERPOOL

IRON CASTINGS

SIR W. H. BAILEY & CO., LTD., ARE PREPARED TO UNDERTAKE ORDERS FOR IRON CASTINGS AT THEIR **PATRICROFT FOUNDRY** AT THE LOWEST POSSIBLE RATES.

Apply: ALBION WORKS, SALFORD, MANCHESTER.

"What the Bradley Service means to the Foundryman."

IN the issue of the "Foundry Trade Journal" for April 12th will appear the first of a new series of advertisements, "What the Bradley Service means to the Foundryman."

The knowledge that comes from long experience is part of the Bradley Service. For instance, carefully recorded and available at any moment, Bradley's have most detailed information concerning actual mixtures that have been tried, tested and proved for specific purposes.

This information and all other assistance is part of the Bradley Service, gladly given free of charge to all who care to make use of it.

Bradley's

PIG IRON

"A QUALITY FOR EVERY REQUIREMENT"

BRADLEY & FOSTER L^TD^ BF DARLASTON, STAFFS.

WEEKLY PRICE CURRENT.

COPPER

	£ s. d.
Standard cash	61 12 6
Three months	61 13 9
Electrolytic	66 10 0
Tough	64 0 0
Best selected	64 5 0
Sheets	92 0 0
India	76 0 0
Wire bars	66 15 0
Do. March	66 15 0
Do. April	66 15 0
Ingot bars	66 15 0
H.C. Wire rods	71 10 0
Off. av. cash, Feb.	61 14 0½
Do. 3 mths., Feb.	61 6 7½
Do., Sttlmnt., Feb.	61 13 11½
Do., Electro, Feb.	66 12 0½
Do., B.S., Feb.	65 15 7½
Aver. spot price, copper, Feb.	61 14 0½
Do., Wire bars, Feb.	66 16 5
Solid drawn tubes	13d.
Brazed tubes	13d.
Wire	9½d.

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	10½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£ s. d.
Standard cash	238 0 0
Three months	237 10 0
English	245 0 0
Bars	247 0 0
Straits	244 0 0
Australian	241 10 0
Eastern	244 10 0
Banca	245 10 0
Off. av. cash, Feb.	233 18 10½
Do., 3 mths., Feb.	236 1 3½
Do., Sttlmt., Feb.	233 18 6½
Aver. spot, Feb.	233 18 10½

SPELTER.

	£ s. d.
Ordinary	25 0 0
Remelted	25 5 0
Hard	20 0 0
Electro 99.9	29 5 0
English	25 10 0
India	21 10 0
Zinc dust	33 0 0
Zinc ashes	8 0 0
Off. aver., Feb.	25 10 2½
Aver., spot, Feb.	25 10 4½

LEAD.

	£ s. d.
Soft foreign ppt.	20 0 0
English	21 10 0
Off. average, Feb.	20 10 3½
Average spot, Feb.	20 5 8

ZINC SHEETS, &c.

	£ s. d.
Zinc sheets, English	33 10 0
Do. V.M. ex whf.	32 0 0
Rods	39 0 0
Boiler plates	29 10 0
Battery plates	31 5 0

ANTIMONY.

	£ s. d.
Special brands, Eng.	58 0 0
Chinese	42 0 0
Crude	34 0 0

QUICKSILVER.

	£ s. d.
Quicksilver	22 7 6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon—	
25%	£8 2 6
45/50%	£12 17 6
75%	£20 10 0
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	4/8 lb.
Ferro-titanium—	
23/25% carbonless	11d.
Ferro-phosphorus, 20/25%	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/3 lb.
Tungsten metal powder—	
98/99%	1/7½ lb.
Ferro-chrome—	
2/4% car.	£32 15 0
4/6% car.	£22 8 0
6/8% car.	£22 5 0
8/10% car.	£22 5 0
Ferro-chrome—	
Max. 2% car.	£35 0 0
Max. 1% car	£40 0 0
Max. 0.70% car	£47 0 0
70% carbonless	1/10 lb
Nickel—99% cubes or pellets	£175 0 0
Ferro-cobalt	9/6 lb.
Aluminium 98/99%	£195 0 0
Metallic chromium—	
96/98%	2/10 lb.
Ferro-manganese (net)—	
76/80%, loose	£13 10 0
76/80%, packed	£14 10 0
76/80%, export	£13 5 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0 2 6
Finished bars, 18% tungsten	£0 3 0

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/8 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£ s. d.
South Wales—	
Hvy. steel	3 5 0
Bundled steel and shrngs.	2 16 0 to 3 1 6
Mixed iron and steel	2 16 0 to 2 17 6
Heavy cast iron	3 0 0
Good machinery for foundries	3 2 6 to 3 5 0
Cleveland—	
Heavy steel	2 17 6
Steel turnings	2 8 6
Cast iron borings	2 3 0
Heavy forge	3 10 0
Bushelled scrap	3 2 6
Cast-iron scrap	3 2 0 to 3 6 0
Lancashire—	
Cast-iron scrap	3 5 0
Hvy. wrought	3 2 6
Steel turnings	2 2 6

London—Merchants' buying prices delivered yard.

Copper (clean)	£52 0 0
Brass (clean)	£38 0 0
Lead (less usual draft)	£17 10 0
Tea lead	£15 10 0
Zinc	£16 0 0
New aluminium cuttings	£75 0 0
Braziery copper	£47 0 0
Gunmetal	£48 0 0
Hollow pewter	£165 0 0
Shaped black pewter	£125 0 0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	82/6
,, d/d Birm.	87/-
Midlands—	
Staffs. common*	—
,, No. 4 forge	62/6
,, No. 3 fdry.	64/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	—
,, fdry. No. 3	58/6 to 59/-
Derbyshire forge	60/-
,, fdry. No. 3	64/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	70/-
Hem. M/Nos.	75/6
Sheffield (d/d district)—	
Derby forge	64/6
,, fdry. No. 3	67/6
Lincs. forge	63/6
,, fdry. No. 3	67/-
E.C. hematite	82/6
W.C. hematite	85/6
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	72/3
Northants foundry No. 3	—
Dalzell, No. 3	100/- to 102/6
Summerlee, No. 3	86/6 to 94/-
Glengarnock, No. 3	86/6 to 94/-
Gartsherrie, No. 3	86/6 to 94/-
Monkland, No. 3	86/6 to 94/-
Coltness, No. 3	86/6 to 94/-
Shotts, No. 3	86/6 to 94/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

	£ s. d.	£ s. d.
Iron—		
Bars (cr.) nom.	9 0 0	to 10 10 0
Angles	—	
Tees to 3 united ins.	—	
Nut and bolt iron	8 17 6	
Hoops	12 0 0	
Marked bars (Staffs.) f.o.t.	12 10 0	
Gas strip	12 0 0	
Bolts and nuts, ¾ in. × 4 in.	15 5 0	
Steel—		
Ship plates	8 7 6	to 8 12 6
Boiler plts.	10 10 0	
Chequer plts.	10 5 0	
Angles	7 17 6	
Tees	8 17 6	
Joists	7 17 6	
Rounds and squares, 3 in. to 5½ in.	7 10 0	
Rounds under 3 in. to ¾ in. (Untested)	7 15 0	and upwards
Flats, over 5 in. wide and up	8 17 6	
Flats, 5 in. to 1½ in.	7 17 6	
Rails, heavy	8 2 6	to 8 7 6
Fishplates	12 10 0	
Hoops (Staffs.)	10 10 0	
Black sheets, 24g.	10 2 6	
Galv. cor. shts., 24g.	13 5 0	
Galv. fencing wire 8g. plain	12 10 0	
Billets, soft	£6 0 0	to 6 10 0
Billets, hard	£7 2 6	to 7 12 6
Sheet bars	£5 12 6	to 5 15 0
Tin bars	£5 12 6	to 5 15 0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 2½
Sheet to 10 w.g.	1 3
Wire	1 3¾
Rods	1 3
Tubes	1 8½
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.76
No. 2 foundry, Valley	17.25
No. 2 foundry, Birm.	16.00
Basic	18.76
Bessemer	19.26
Malleable	19.01
Grey forge	18.51
Ferro-mang. 80% d/d	100.00
Bess rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	34.00
Wire rods	44.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.85
Tank plates	1.85
Beams, etc.	1.85
Skelp, grooved steel	1.85
Skelp, sheared steel	1.85
Steel hoops	2.20
Sheets, black, No. 24	2.90
Sheets, galv., No. 24	3.65
Sheets, blue an'l'd., 9 and 10	2.10
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv.	3.35
Tinplate, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	—
,, furnace	14/-
Other Districts, foundry	—
,, ,, furnace (basis)	12/- to 13/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes	20×14	box	18/-
,,	28×20	,,	36/-
,,	20×10	,,	—
,,	18¾×14	,,	—
C.W.	20×14	,,	16/10½
,,	28×20	,,	—
,,	20×10	,,	—
,,	18¾×14	,,	—
Terneplates	28×20	—	per box basis f.o.b.

SWEDISH IRON.

Bars, hammered,	£17 10 0 to £18 10 9
Rolled Ord.	£15 0 0 to £15 10 0
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings.*
Gas	67½%	45%
Water	63¾%	40%
Steam	60%	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Mar. 22	61	7	6	inc.	2/6
„ 23	61	5	0	dec.	2/6
„ 26	61	7	6	inc.	2/6
„ 27	61	11	3	„	3/9
„ 28	61	12	6	„	1/3

Electrolytic Copper.

	£	s.	d.	
Mar. 22	66	10	0	No change
„ 23	66	10	0	„ „
„ 26	66	10	0	„ „
„ 27	66	10	0	„ „
„ 28	66	10	0	„ „

Standard Tin (cash).

	£	s.	d.		
Mar. 22	238	10	0	inc.	70/–
„ 23	240	2	6	„	32/6
„ 26	239	10	0	dec.	12/6
„ 27	239	17	6	inc.	7/6
„ 28	238	0	0	dec.	37/6

Tin (English ingots).

	£	s.	d.		
Mar. 22	244	0	0	inc.	140/–
„ 23	245	5	0	„	25/–
„ 26	244	10	0	dec.	15/–
„ 27	245	0	0	inc.	10/–
„ 28	245	0	0	No change	

Zinc Sheets (English).

	£	s.	d.	
Mar. 22	33	10	0	No change
„ 23	33	10	0	„ „
„ 26	33	10	0	„ „
„ 27	33	10	0	„ „
„ 28	33	10	0	„ „

Spelter (ordinary).

	£	s.	d.		
Mar. 22	25	3	9	inc.	6/3
„ 23	25	3	9	No change	
„ 26	25	3	9	„	„
„ 27	25	2	6	dec.	1/3
„ 28	25	0	0	„	2/6

Lead (English).

	£	s.	d.		
Mar. 22	21	15	0	inc.	10/–
„ 23	21	15	0	No change	
„ 26	21	10	0	dec.	5/–
„ 27	21	10	0	No change	
„ 28	21	10	0	„	„

AVERAGE PRICES OF STEEL RAILS.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	£ s. d	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908 ..	6 2 6	6 0 0	6 0 0	5 15 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 16 3
1909 ..	5 5 0	5 5 0	5 5 0	5 0 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0
1910 ..	5 5 0	5 7 6	5 7 6	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 8 11½
1911 ..	5 15 0	5 15 0	5 15 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 13 1½
1912 ..	5 13 1	5 15 0	5 15 0	5 15 7	6 1 6	6 6 3	6 7 6	6 8 0	6 11 3	6 12 6	6 12 6	6 13 9	6 4 4
1913 ..	6 15 0	6 14 4½	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	6 12 0
1914 ..	6 10 0	6 10 0	6 6 3	6 0 0	6 0 0	6 0 0	5 14 0	6 2 6	6 13 9	6 12 0	6 7 6	6 7 6	6 5 3½
1915 ..	6 10 6	6 17 6	7 5 0	7 12 6	7 12 6	7 17 6	8 17 6	9 2 6	9 2 6	9 2 6	9 7 6	10 10 6	8 6 6½
1916 ..	10 19 4	11 0 0	11 0 0	10 18 9	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 9 10
1917 ..	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1918 ..	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1919 ..	10 17 6	13 7 6	13 7 6	13 7 6	15 0 0	15 10 0	16 0 0	16 10 0	16 10 0	16 10 0	16 10 0	17 5 0	14 12 11
1920 ..	18 15 0	19 5 0	20 7 6	22 0 0	23 0 0	23 0 0	24 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	22 18 11½
1921 ..	23 5 0	20 4 0	18 0 0	17 0 0	15 0 0	15 0 0	14 0 0	14 0 0	14 0 0	11 12 6	10 10 0	10 0 0	15 4 3
1922 ..	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 0 0	8 15 0	8 15 0	8 15 0	8 15 0	9 4 2
1923 ..	8 17 6	9 2 0	10 5 0	10 10 0	10 10 0	10 10 0	9 15 0	9 0 0	8 15 0	8 15 0	8 19 0	9 5 0	9 9 10
1924 ..	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 2 6	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 2 3½
1925 ..	9 0 0	9 0 0	9 0 0	9 0 0	8 15 0	8 10 7½	8 10 0	8 10 0	8 10 0	8 4 0	8 0 0	8 0 0	8 11 7½
1926 ..	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 10 0	8 3 11½
1927 ..	8 10 0	8 10 0	8 10 0	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 3 0	8 5 0	8 5 0	8 4 10
1928 ..	8 5 0	8 5 0	8 5 0	—	—	—	—	—	—	—	—	—	—

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Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct	Nov.	Dec.	Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1915 ..	83 11	88 6	94 8	107 0	102 6	101 3	98 9	98 7½	96 6	104 0	124 1	130 0	106 11½
1916 ..	133 9	140 0	136 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	128 1½
1917 ..	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1918 ..	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1919 ..	122 6	122 6	122 6	122 6	179 2	190 0	197 6	200 0	200 0	200 0	200 0	200 0	171 4
1920 ..	220 0	220 0	240 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	251 8
1921 ..	240 0	220 0	180 0	180 0	180 0	160 0	160 0	160 0	137 0	127 6	117 6	104 6	162 2
1922 ..	97 6	91 7½	100 0	98 6	97 1½	94 7	93 6	90 9	89 7	91 10½	93 0	93 2	94 5½
1923 ..	94 6	104 9	122 0	126 10½	122 0	115 3	107 0	98 8½	98 10½	99 1½	100 6½	102 3	107 10½
1924 ..	102 4½	101 3	99 7½	99 0	98 9½	97 4½	95 3½	93 1½	90 7½	88 0	88 4½	88 6	95 2½
1925 ..	87 5	85 9	84 7½	82 6	80 10½	79 3	77 1½	75 7½	75 0	74 3½	74 9	76 0	79 5½
1926 ..	77 3	77 9	77 3½	76 3	77 4½	78 0	79 8½	81 9	83 4½	87 7½	92 6	90 5½	81 7½
1927 ..	90 0	90 0	86 3½	83 1½	80 6	78 0	76 6	75 4½	75 0	72 9	71 9	71 1½	79 2½
1928 ..	69 7½	69 7½	69 9	—	—	—	—	—	—	—	—	—	—

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